APPROACH TO THE MAIN GATE OF THE GARDEN.

An Avenue of Silver Maples.

MISSOURI

BOTANICAL GARDEN.

THIRD ANNUAL REPORT.

ST. LOUIS, MO.:
PUBLISHED BY THE BOARD OF TRUSTEES.
1892.

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* *Ex-officio.*

1 Elected April 9th, 1890, to fill the vacancy caused by the resignation of Judge Samuel Treat, one of the Trustees named by Mr. Shaw.

2 Elected December 18th, 1889, to fill the vacancy caused by the resignation of M. Dwight Collier, one of the Trustees named by Mr. Shaw, but who had removed from the city.

3 Elected President of the School Board November 10th, 1891, in place of C. F. Miller, who met with the Board until that date.

4 Elected Chancellor of Washington University October 16th, 1891, up to which time the office had been vacant, since the organization of the Board.

5 Elected President of the Academy of Science January 4th, 1892, in place of F. E. Nipher, who met with the Board until that date.

PREFACE.

Under direction of the Board of Trustees of the Missouri Botanical Garden, its third annual report is presented to the public. As best calculated to promote the objects of publication, the diffusion of information concerning the institution and of the results of scientific work done in connection with it, it has been decided that an annual volume shall be issued in the early part of the year, containing the official report of the President of the Board and the Director of the Garden for the preceding year, together with such other matter as is considered pertinent. These volumes are primarily intended for distribution to botanical gardens, learned societies, and other scientific institutions, whose publications are desired in exchange; but when reason exists for it, they may also be sent to public libraries, or to individuals, although as a rule the latter cannot be carried on the regular mailing list for this purpose.

The pages of each report are electrotyped, and in order that scientific papers may be issued promptly on their completion, it has been decided that they may then be published, in advance of the volume, for which the electrotyped pages, bearing their original pagination at the bottom, will be held. In case of priority questions arising, therefore, when separates have been issued in advance, reference must be made to these for actual date of publication. Separate copies of all scientific papers are printed, so that botanists not in receipt of the complete reports may be supplied with those papers which are useful in their work.

For the accommodation of persons who may wish the publications of the Garden, but feel that they are not entitled to receive them by way of exchange or as aids to

scientific work, a few copies are offered for sale at about the cost of publication ($1.00 each, for the reports already issued, including the present, and 50 cts. for the revision of Epilobium reprinted from the second report) at the gate of the Garden, and by Dr. A. E. Foote, of Philadelphia, W. Wesley & Son, of London, and R. Friedländer & Sohn, of Berlin. Applications for the purchase or exchange of either reports or separate papers may be made also to the Director of the Garden.

WILLIAM TRELEASE.

ST. LOUIS, Jan. 14, 1892.

YUCCA TRECULEANA.

CONTENTS.

LIST OF ILLUSTRATIONS.

YUCCA BACCATA.

REPORTS FOR THE YEAR 1891.

REPORT OF THE OFFICERS OF THE BOARD.

SUBMITTED TO THE TRUSTEES JAN. 13TH, 1892.

To the Board of Trustees of the Missouri Botanical Garden:

Since the last annual report many extensive and permanent improvements to the buildings and grounds have been completed, and others are under way, which have necessitated a large expenditure of money, but the results have been eminently satisfactory, and the Garden greatly improved thereby.

The reconstruction of the Garden residence of the late Henry Shaw, which is now used as a residence by the Director of the Garden, and which was about finished at the beginning of the past year, has been entirely completed, and the building is furnished in a suitable manner. Extensive repairs and improvements to the Museum building, and a boiler house and steam plant, costing in the aggregate about $18,000, have nearly all been paid for during the past year.

Mr. Shaw, in the thirtieth paragraph of the third clause of his will, expressed a desire that his late city residence, located on the southwest corner of Seventh and Locust streets, should be carefully taken down and rebuilt on Tower Grove avenue in some convenient location contiguous to the Garden, for which purpose he left the sum of $10,000. As a desirable tenant was secured for the premises, on a lease for 100 years, it became necessary to remove the building, but as the lowest

estimate for the removal and rebuilding of the residence was far in excess of the amount left for the purpose, the Board deemed it wise to apply to the courts for instruction in the matter. Judge Jacob Klein, of the Circuit Court of St. Louis, decided that the building must be removed and rebuilt, as near as possible like the original, using the same material as far as practicable, regardless of the cost, and that any amount in excess of the sum designated by Mr. Shaw for the purpose must be paid out of the income of the Trust. As additional room was needed for the Library and Herbarium, you decided to construct the building with that purpose in view, and on account of the inflammable and valuable nature of its contents it was deemed best to make the building as near fire-proof as possible. Contracts were made for the removal and rebuilding, and work was begun in March and finished in December, and the building is now occupied, the contracts having been satisfactorily carried out, at a total cost, including heating, plumbing, etc., of $33,478.89. The building is an ornament to the Garden.

These heavy expenditures, many of them unavoidable, have largely reduced our surplus of January 1, 1891, besides exhausting our income for the past year, but inasmuch as all the most important and necessary improvements have been made and paid for, the outlay for the coming year will be very much less.

For improvements to the Garden you are referred to the Director's annual report.

The cash receipts and expenditures for the past year are as follows: —

RECEIPTS.

Rent account, including uncollected rents, 1891	$85,692 80	
Garden account, sales	459 89	
Stock account, sales of wines, etc	1,828 98	
Insurance of rents on account of loss by fire	216 67	
Removal of residence (Public Administrator)	10,000 00	98,198 34
Cash on hand January 1, 1891		24,205 23
Total receipts		$122,403 57

EXPENDITURES.

Office expense —		
Salary	$2,500 00	
Rent of office	450 00	
Stationery, printing, etc	951 11	3,901 11
Garden expense —		
Labor	20,192 37	
Fuel	1,066 81	
Stable, feed, etc	813 79	
Repairs and supplies	7,701 46	
Lodge and pupils	1,402 62	
Plants, seeds, etc	1,020 49	
Herbarium	3,199 70	
Library and subscriptions	4,261 36	
Garden office expense	5,174 25	44,832 85
Garden improvements (Director's residence)		11,785 35
Property expenses —		
Commissions	3,040 72	
Streets, pavements, etc	1,489 48	
Taxes (sprinkling)	1,332 36	
Insurance	3,301 84	
Repairs	4,944 84	14,109 24
Sundry accounts —		
Legal expenses		841 45
Publications		1,465 05
Flower show		460 00
Flower sermon		200 00
Gardeners' banquet		381 80
Trustees' banquet		914 90
Washington University (School of Botany)		1,774 86
Removal of residence		33,478 89
		$114,145 50
Cash on hand January 1, 1892		8,258 07
		$122,403 57
Financial condition January 1, 1892 —		
Cash on hand and in bank		$8,258 07
Less amount due Capital Stock for sundry sales		2,332 98
Balance		$5,925 09

The books of the Board have been closed after showing the operations for the year ending December 31, 1891, and the receipts have been disposed of as follows: —

Rent account to January 1, 1892, including uncollected rents January 1, 1891		$85,692 80
Less uncollected rents for 1891		7,349 50
Rents collected in 1891, 11 months		78,343 30
Surplus January 1, 1891, including uncollected rents for 1891		31,050 73
		$109,394 03

CONTRA.

Garden expenses	$44,372 96	
Office expenses	3,901 11	
Commission (for collecting rents)	3,040 72	
Repairs (to revenue property)	4,944 84	
Insurance	3,085 17	
Taxes (sprinkling)	1,332 36	
Streets, pavements and sewers	1,489 48	
Legal expenses	841 45	
Washington University (School of Botany)	1,774 86	
Trustees' annual banquet	914 90	
Gardeners' " "	381 80	
Publications	1,465 05	
Garden improvements (Director's residence)	11,785 35	
Annual flower show	460 00	
Annual flower sermon	200 00	
Removal and rebuilding Shaw residence	23,478 89	
Surplus January 1, 1892	5,925 09	
	$109,394 03	$109,394 03

Respectfully submitted,

R. J. LACKLAND, *President.*

Attest,

A. D. CUNNINGHAM, *Secretary.*

YUCCA FILIFERA.

THIRD ANNUAL REPORT OF THE DIRECTOR, FOR 1891.

SUBMITTED TO THE TRUSTEES JAN. 13, 1892.

To the Board of Trustees of the Missouri Botanical Garden:

In compliance with the rules of the Board, I respectfully submit the following report on the Missouri Botanical Garden and the Henry Shaw School of Botany.

THE BOTANICAL GARDEN.

During the past season no effort has been spared to maintain and augment the ornamental features of the Garden, so far as the funds at the disposal of the Board permitted, and to make it both pleasing and instructive to the public. The number of visitors during the year, so far as can be estimated in the absence of automatic registers, has been somewhat greater than in 1890, and on the open Sundays, in June and September, very large numbers of people visited the grounds. With few exceptions visitors have been orderly, and little damage has been done to property.

Throughout the year about fifty men have been employed on the grounds, at an aggregate expense of something over $20,000.00 for the year. Besides the necessary work of maintenance, many repairs and improvements have been made. These have been reported in detail in my monthly reports. By way of summary it may be said here that they have included excavating and remaking in a substantial manner some 5,100 running feet of walks; laying about 3,200 feet of drain and sewer pipe, and making the necessary surface connections and silt pits; resetting 3,380 feet of brick edging; grading and laying sod on about 13,000 square feet of ground, and grading and seeding about 30,000 square feet of lawn; removing the unsightly shed and broken fences from the rear and sides of the

vegetable garden; repairing various fences, well-houses, and summer houses, and the farm barn, which had become very dilapidated and insecure; tearing down and rebuilding from the foundations the west wing of the main greenhouse, to which reference was made in my last report; and thoroughly pointing and painting the main greenhouse inside and out. All of the sets of steps about the parterre, which had become much decayed, have been removed and reconstructed in granitoid; the dilapidated wooden fence at the rear of the residence has been rebuilt, the center in granitoid and iron; a refrigerating drinking fountain has been set at the gate of the Garden; and the very unsightly and decayed picket fence along the north front of the arboretum, 1,040 feet in length, has been replaced by a neat barbed wire fence with ornamental cresting, thus opening up a very pretty view into the grounds to persons driving along Shaw avenue.

In accordance with plans previously announced, a beginning has this year been made toward putting the fruticetum in order by removing some of the old and useless trees and nursery stock; subsoiling 210,600 square feet of ground (in the main already underdrained), of which 33,525 square feet was spaded 30 inches deep, 10,500 square feet 24 inches deep, and the remainder about 10 inches deep; replacing the broken brick edging of walks in the southeastern quarter of the inclosure by sod 20 inches wide; and planting a small experimental orchard, comprising 68 varieties, of which 19 are apples, 4 peaches, and 15 grapes. In addition to containing the necessary orchard, it is intended that the fruticetum shall be made to correspond with its name by growing in it specimen shrubs, representing as great a variety of species as is practicable in the restricted area.

Notwithstanding the extent of the repairs and improvements executed during the past two years, and regardless of any material extension of the Garden and its greenhouses, this work can scarcely be said to be more than begun, since

it may be found necessary to reroof the Agave house during the coming season, in addition to making repairs on other greenhouses, while the smoke issuing from the flues of all of these houses when the fires are replenished late in the afternoon, is so objectionable that one of the first large improvements contemplated must be the provision of a single central stoke hole, containing boilers sufficient to heat all of the plant houses and provided with adequate smoke-consuming devices. The walks of arboretum, fruticetum, and vegetable garden, which in bad weather are very unsatisfactory, must also be remade in a substantial manner, as this work can be afforded; and considerable additional fencing is required to place the grounds in a presentable condition, a neat barbed wire fence between the arboretum and fruticetum being particularly desirable.

For the first time in my experience, the entire grounds have been kept free from weeds through the year, and in most respects a creditable appearance has been maintained. Owing to the severe drought during the entire summer and autumn, however, and the inadequacy of the city water supply through the same period, the lawns suffered even more than in 1890, the blue grass being entirely destroyed and replaced by annual species over large areas.

In addition to procuring numerous plants for the greenhouses, among which should be mentioned numerous species brought from the West Indies by Mr. Hitchcock, a systematic effort has been made to introduce hardy native species into the grounds. For their accommodation a bog and artificial pond were made, and many small beds prepared in the southern part of the arboretum. Under the direct care of Mr. F. H. Horsford, an experienced grower of native plants, some 1,500 species were introduced, of which the greater number are established, though the severity of the season and the refractory character of the soil have rendered success much more difficult of attainment than has usually been the case in Mr. Horsford's experience. The number of species already planted in this "wild garden" is about

equal to the entire phænogamic flora of a State, and rather greater than that of the British Islands. While several years must pass before the best results can be hoped for, and some of the species may require frequent renewal, this part of the Garden is a most essential one, and during the past year the plants in it have proved attractive to many visitors, and have been particularly interesting and instructive to pharmacists who have visited the grounds, inasmuch as the collection includes a large number of officinal plants.

Several hundred tree labels have been placed in the course of the year, some consisting of metallic plates coated with "granite ware" enamel, in which the names were fired in a contrasting color, while others are of a "white bronze" alloy now much used in monument work, and bear the names in raised letters. As rapidly as possible, all of the trees are being named in this manner. Shrubs are labeled by means of plates of celluloid, bearing the names in indelible ink, and affixed by copper wire; and the same kind of labels, wired to long iron rods capable of being thrust far enough into the ground to escape displacement by frost, is being employed for herbaceous plants in the bog and other parts of the wild garden.

The herbarium has been augmented by the purchase of the more important current collections of American plants offered for sale during the year, as well as by the purchase of a very full set of the grasses in the herbarium of the late Dr. George Thurber, and the acquisition of many desirable specimens through exchange and the donations of correspondents, to whom the thanks of the institution are tendered. As a result of the collecting cruise of Mr. Hitchcock in the West Indies, referred to in my last report, some 2,000 valuable specimens, representing very fully the flora of the islands he visited, have been added to the herbarium, which, together with that part of the library referring to the botany of the same region, is believed by Mr. Hitchcock to be now quite as complete as any in the country.

The Engelmann and Bernhardi herbaria, referred to in my last report, have now been mounted and arranged, and it appears that their contents are as follows:—

Engelmann Herbarium, about 98,000 specimens.
Bernhardi " " 57,500 "

In accordance with a plan formed several years since, my private herbarium, chiefly of fungi, including about 11,000 specimens representing some 4,000 species, was donated to the Garden in November last, and will form the nucleus for a collection of thallophytes which will be gradually brought together. In accepting this gift, which was made because of my belief that no person intrusted with the care and increase of a public collection can at the same time work for a private collection without serious detriment to the former, the Board indorsed this opinion, and voted that employees of the Garden shall hereafter be allowed to form private collections only by the written permission of the Director.

In compliance with the requirements of Mr. Shaw's will, the residence formerly occupied by him at the corner of Seventh and Locust streets has been rebuilt within the southeastern angle of the stone wall inclosing the grounds (G5, of map published in first report), facing on Tower Grove avenue. In its present condition, the building is fire-proof, and has been set apart for the use of the herbarium and library. Together with the Museum and the residence of the Director, this building is heated by steam from a boiler pit located at a safe distance from all.

Owing to heavy expenses in other directions, the library has been added to more slowly during the past year than in 1890, but some $4,300.00 has been expended on it, and the additions include a number of valuable and scarce works and sets of journals. In connection with the herbarium already referred to, my collection of about 500 books and 3,000 pamphlets was presented to the Garden, and will be incorporated in the general library, which now contains

some 6,000 volumes, — many of them composed of pamphlets and hence representing a number of titles much greater than this. As I had hoped might be the case, the exchanges of publications offered the Garden are increasing, and some 185 institutions have already placed the library on their mailing lists.

With the transfer of the herbarium and library to their new quarters, the small museum room will become vacant again, and it is proposed to arrange in it an instructive synoptical collection in either systematic botany or some branch of economic botany; but the expense and slowness of making a suitable and properly arranged collection, even though it be small, are such as to render it improbable that the building can be opened to the public during the coming year.

Throughout the year Mr. Duffey has given to experimental work, and observations on noxious insects, such time as could be spared from his practical duties. The principal results of his work in spraying plants for the destruction of injurious insects and fungi were presented by him to the State Horticultural Society, at its recent meeting in Sedalia, and will be published, with illustrations, in the forthcoming report of the Society. Among the practical results reached was the discovery that by forcibly spraying the smaller cacti with pure water by means of a force pump and Vermorel nozzle, the mealy bugs, so troublesome because of their habit of ensconcing themselves between the bases of the spines, may be dislodged without injury to the plants and at less than one-fourth of the usual expense, since it has heretofore been thought necessary to remove them individually by hand, by the aid of brushes or pointed bits of wood, — a laborious process which, moreover, sometimes results injuriously to the plants. As a result of Mr. Duffey's leave of absence, reported a year ago, he has been enabled to determine the scale insects of the Garden satisfactorily, and now has in hand observations on the life history of several representatives of this injurious group.

The collections made in the West Indian region by Mr. Hitchcock, and to which I have already referred, have occupied the greater part of such time as he could spare from routine work during the year, and, to afford him access to type specimens and certain works not in the Garden library, he was allowed to spend the greater part of December last at the Herbarium of Harvard University, making brief stops also at Columbia College, and the Department of Agriculture at Washington. As a result of his studies he has prepared a somewhat lengthy paper, which is believed to be a useful contribution to the botany of the region, and which will be published in the fourth Garden volume. The only botanical work which I myself have been able to complete during the year is a revision of our species of *Rumex*, which will soon be published.

Since my last report was submitted, two garden pupils have resigned their scholarships, — one to enter his father's business as a florist, the other through lack of interest in gardening. Only two awards were made in 1891, and the plans of one of the new appointees were changed shortly after he had received a scholarship, so that virtually only one was awarded. The character of the work done by pupils has been satisfactory in the main, though it is not always easy to convince them of the necessity for a thoroughgoing interest in every step taken. In addition to the requisite manual work, the second year pupils have received theoretical instruction in the studies for that year, from Mr. Duffey and Mr. Gurney. In November last a third announcement was issued, in which it was stated that three scholarships were to be awarded prior to the first of April, 1892, one of the number being reserved from competition, for the use of the St. Louis Florists' Club.

Four annual events provided for under the will of Henry Shaw, have taken place in the course of the year, viz.: the delivery of the second flower sermon, in Christ Church Cathedral, by Rev. Montgomery Schuyler; the second

banquet to the Trustees of the Garden and their guests, presided over by the Bishop of Missouri; the second banquet to gardeners, florists and nurserymen, presided over by the Director of the Garden; and the award of the first Shaw premiums at a floral exhibition, given under the auspices of the Florists' Club of St. Louis.

The flower sermon will be printed in the third report, which will also contain abstracts of the proceedings at the two banquets. The premiums authorized by the 25th paragraph of the 4th clause of Mr. Shaw's will, which were awarded by the Florists' Club at its Chrysanthemum show in November last, under the direction of the Board of Trustees of the Garden, were offered for subjects calculated to broaden the scope of florists' work, and to afford opportunity for visitors to the exhibition to become familiar with choice specimens of plants not ordinarily found in the floral establishments of the city. To this end, competition for these premiums was opened to the general public without fee or reservation, and as a result of this liberality on the part of the Florists' Club, several valuable collections and specimen plants were exhibited from the middle and eastern States. Awards were made for orchids, $150.00; new seedling Chrysanthemum, $50.00; Dracænas, $30.00; Cycads, $15.00; Pandanus, $30.00; Araucarias, $15.00; Palms, $135.00; and other decorative plants, $30.00: —together $460.00. A series of premiums amounting to $40.00, offered for a collection of Oxalis plants, which are deserving of more general cultivation by amateurs than they receive, was not competed for.

THE SCHOOL OF BOTANY.

Since the presentation of my last report I have been assisted by Mr. Webber, who has attended to the necessary routine work of the School, including preparations for the regular lectures to undergraduates which are delivered by me. He has also conducted, under my direction, the laboratory electives for undergraduates, and special classes

YUCCA FILIFERA.

in systematic botany, germination of seeds, and histology, and has taken special students for work on roots, biological botany, and fungi. A special class studied the structure and life history of ferns and mosses in the spring, under my instruction and that of Mr. Webber, and a class in analytical botany, which met at the Garden in the spring, was carried on partly by myself and in part by Mr. Hitchcock. Mr. Webber has continued his studies for the Doctor's degree, giving considerable time to germination work, and has also found time to prepare an important supplement to the Flora of Nebraska published some time since by Professor Bessey in connection with him, and will soon issue it as a contribution from the School.

So far as number of students and character of work done are concerned, there is no essential change from what was set forth in my last report. The facilities for special work afforded by the Garden and School of Botany have been made use of during the year by several botanists engaged in special work, and the results of work done at the School of Botany by Professor Pammel, of the Iowa Agricultural College, have just been published, constituting the eighth contribution from the School. Owing to depreciation in the value of the property constituting the endowment of the School, which from yielding an annual rental of $5,400.00 when I was called to the School of Botany, has now come to yield something less than the $3,500.00 guaranteed by Mr. Shaw's will, the available income is at present nearly consumed by the necessary salaries, so that for the past year no large addition has been made to either the library or instrumental equipment of the School. It has, however, proved possible to secure the few additions absolutely needed for the prosecution of current work; the material and library of the Garden have been freely drawn on when needed; and, when the occasion for such action arises, it will be possible for the Garden Board, if they think it expedient to do so, to supplement the income of the School of Botany by augmenting the means and appli-

ances of instruction, under the authority given in the third paragraph of the second clause of Mr. Shaw's will.

In closing this report I wish to express my appreciation of the interest and support given by the Board of Trustees, and in particular by the Garden Committee, during the past year; and of the faithful and able co-operation of my assistants, both at the Garden and the School of Botany.

Respectfully submitted,

WILLIAM TRELEASE,

Director.

St. Louis, Mo., Jan. 13, 1892.

YUCCA BREVIFOLIA.

ANNIVERSARY PUBLICATIONS.

SECOND ANNUAL FLOWER SERMON.

BY THE REVEREND MONTGOMERY SCHUYLER.

1st Kings, Chap. IV., 33d Verse (Part).

"And he spake of trees, from the cedar that is in Lebanon, even unto the hyssop that springeth out of the wall."

At the request and by the appointment of the Bishop of the diocese, I am the second under the provision of the will of the late Henry Shaw, to preach on the "Wisdom and Goodness of God, as shown in the growth of Flowers, Fruits and other products of the Vegetable Kingdom." It may not be amiss in me, as it was my privilege to have been personally acquainted with the testator for many years, and as it is not probable that such a privilege has been accorded to others who may succeed me, to speak of him, in the character under which he is brought before us, by this special bequest.

Though not known by public profession as a Christian man, he was baptized in infancy in the English Church, and retained through life a deep reverence for her teaching, and devotion to her forms of worship. He was not a man indifferent to religion, or inimical to the great truths of a written revelation. The motto he left inscribed on his mausoleum, — "How manifold are Thy works, in wisdom hast Thou made them all, the earth is full of Thy riches," joined with that other motto, in striking prominence in the Garden, "Glory to God in the Highest, on earth peace, good will to men," — bespeak a reverence for the Bible indicative of marked religious feeling.

Since I was asked to preach this sermon, I have thought often, and earnestly of this unique provision of the will;

have tried to form some probable conjecture of the mental phase of its author; and of the nature of the motives which may have prompted the thought. The will in its inception was of grand and noble birth; and in the variety and multitude of its provisions, must have occupied, not merely days and weeks, but months in its elaboration. It involves careful and comprehensive thought, to put in order and proper proportion the varied considerations to be embraced, in answering the demands of the present, and providing for the ever-increasing and ever-varying developments growing out of the passage of years, and in all probability of centuries. Here was a princely estate, and an exceptional field for the exercise of a public spirit, devoid of all selfishness, and looking forward to a kindly provision for the pure pleasure and harmless enjoyment of generations to come, and for the permanent protection of a science, second to none in interest and importance; and that too with a munificence and far-reaching wisdom, of which the history of this country has furnished no precedent.

How often, as he took his seat in his fairy-like Garden, with the flowers smiling all around him, yielding their grateful fragrance as incense for their loving culture — how often, must his thoughts have traveled onward to the time when another father would be there to look after his children. And how naturally then, would arise the wish to perpetuate himself in such case: and doubtless it was from such a wish, that the thoughts grew and took shape, which were afterward embodied in distinct clauses of his last will and testament. Was it not one of these little preachers, or it may be, a bright company of them blooming at his feet, that lifted his thoughts heavenward; chanting in his ears the praises of the High and Lofty One, inhabiting eternity, who yet beautifies His footstool by painting the petal of the lily and the rose, and covering the checkered surface of the earth with its carpet of emerald? It must have been a consonance of thought and feeling with such

aspirations, which led to the determination that the lessons of these mute preachers should not be lost: and hence, the provision, that an interpreter of these voices should not be wanting to illustrate and enforce what they were daily teaching. There was deep religious feeling at the bottom of this provision; not exhausting itself in simple introspection; but, embracing the Deity as well as humanity, seeking to promote the glory of God and the good of man, by reiterating through the centuries the lessons of the divine wisdom and goodness.

In the spring of 1874, Canon Kingsley, the enthusiastic botanist, as well as broad-minded, warm-hearted man, world-renowned for his literary labors and philanthropic efforts, visited our city; and it was my privilege to take him to the Garden and introduce him to its unassuming proprietor. At once there sprang up between them a sympathy in the cultured devotion to a favorite science, that made their brief intercourse a mutual delight. We visited the choice and extensive collection of exotics, and the Canon showed himself as familiar with their botanical names, as if they were the members of his own family, and discoursed as readily of their several habitats and distinguishing characteristics, as of old acquaintances. This quickly insured the full sympathy and confidence of his host, and there was no lack of topics of conversation between them, among the wonders of the vegetable world. "With the exception of the Kew Garden," (said Canon Kingsley,) "I have seen nothing in any part of the world, that compares with the rarity and variety of the collection here." And on our return to the city he remarked, that he was amazed that there had been so little recognition on the part of our people of the immense service done by Mr. Shaw to the cause of science, and apparently so little respect shown to him personally. And he warmly expressed his intention, upon his return to England, of securing in his behalf the honor of an appointment as a Fellow of the Royal Society. But he was not permitted to carry out his

generous purpose. His days were numbered. He returned to his home in August; on the 29th of the following November, preached his last sermon in Westminster Abbey; and in January, 1875, was laid to his rest; leaving the record of an eminently useful life, whose influence will be felt through the ages to come in the works of genius he has left behind.

It has been said that devotion to the memory of a mother's love, is akin to the reverential devotion to Deity itself. And such was the devotion of Henry Shaw to the mother who bore him. Well do I remember the kind invitation I received more than 30 years ago, to join him with a party of friends at a dinner in commemorating his mother's 81st birthday. Reticent as he naturally was, there were only slight allusions in passing words, to the occasion of the gathering, but every member of the company knew and felt in sympathy with what was passing in the mind and heart of their host. A still more touching instance of this devotion, is the incident which occurred on the day of his death. A few hours only before he bade a long adieu to the scenes of earth, when his mind was clear and his memory undimmed, he asked his faithful attendant, that she would bring his mother's prayer book, which he had cherished for years as a priceless treasure, and which was lying close at hand, and read to him the Psalter for the day.

His biographer, who has written in such choice English, without exaggeration, and in honest truth, the simple story of his life, referring to his mother, remarks as it were incidentally, "whom he most resembles in disposition." And again, "His naturally high temper" (which, by the way, his faithful attendant of nearly twenty-five years assured me she never saw exhibited) — "his naturally high temper was under such complete control that few ever suspected its existence." "In twenty-three years" (says Mr. Gurney, head gardener), "I never heard him speak a harsh or irritable word, no matter what went wrong;

and in such a place, and with so many men, things will go wrong occasionally; he was always pleasant and cheerful, making the best of what could not be helped." Nor did he live in and for the present alone. He used to say when planting Tower Grove Park, a task in which he delighted, that he did not expect to see these children reach their maturity, that "he was planting them for posterity." Nor, while doing this, was he in his unambitious nature, thinking of himself; nor did he realize that he was building for himself a name that would outlive the longest lives of these, his children.

In concluding these personal allusions, there is one significant fact to which I would point, as a marked witness to the religious sentiments of the late Henry Shaw. Unlike most men he did not shrink from having a reminder of his mortality ever before his eyes. He could not leave his house to take his accustomed seat amid the bright life of leafy shrubs and blooming flowers, without passing the spot he had chosen for his last resting-place. "If a man die, shall he live again," must have been a question, often appealing to his mind, in the routine of his daily walk; and when sketching the plan of his mausoleum, what prompted the thought to crown it with the emblem of our Salvation? There it stands and there it will stand, to preach the grand lesson of the Incarnation, and to remind the passer-by of that noblest example of self-sacrifice, culminating in the saving efficacy of the atonement.

I know, brethren, you will pardon this long preface, though it must necessarily shorten a fuller consideration of the proper subject of the sermon.

It is said of Solomon in the text: "And he spake of trees, from the cedar tree that is in Lebanon, even unto the hyssop that springeth out of the wall."

The cedar of Lebanon was the king of the forest in the Holy Land; and there is reason to believe that some of these noble specimens of creative power, are still standing, which have breasted the storms of thirty centuries.

Of the "hyssop that springeth out of the wall," it is thought to have been a short-lived, insignificant herb, most probably a species of moss which grew upon the damp places of the wall, and was least likely to attract the notice of a casual observer, or enlist the attention of those who had not made a special study of the vegetable kingdom. By selecting the extremes of that kingdom, as fitting representatives of the discriminating and all-embracing knowledge of Solomon, with its multifarious and widely scattered members, the sacred historian has given us to understand, that as in other fields his remarkable wisdom had been displayed, so in this special branch of science were his investigations alike conspicuous.

That the wisdom of Solomon was widely extended, embracing every species of knowledge, having been, as we are taught, specially endowed by the All-Wise, is apparent from the context, "And God gave Solomon wisdom and understanding exceeding much, and largeness of heart." Wisdom has been defined "knowledge rightly used," and again "the pursuit of the best ends by the best means."

The context asserts that "he spake three thousand proverbs, and his songs were one thousand and five." In such of the proverbs as are extant we have examples embracing all the relations of life; eminently practical, as rules for the guidance of the statesman, the legislator, the teacher of morals and religion, or the private citizen in his domestic duties.

The age of Solomon was the golden age of the Kingdom of Israel. Under the warlike rule of his father David, that kingdom had rapidly gained the ascendancy over the neighboring powers. Their isolated position no longer held them aloof from intercourse with others, nor did it interfere with the liberal cultivation of the arts and sciences. The forty years of the peaceful reign of Solomon, especially during its early period, were devoted to the more general elevation of the people in the social scale; and to a more liberal education among all classes, the refining in-

fluences of which continued long after the barbaric wealth and wasteful superabundance begotten by their semi-enlightenment had passed away. That early in life, after his endowment with marvelous wisdom, Solomon's attention was directed to the study of the vegetable kingdom, is altogether probable.

The words of the text, critically examined, convey more than the idea, that trees and herbs were at times the topic of conversation. The better translation would be, "he treated of plants," extending his observation over external nature, involving the widest survey and the minutest discrimination. St. Irenæus, one of the earliest fathers of the Church, says: "Solomon expounded physiologically, the wisdom that is apparent in the creation." The Koran asserts that Solomon understood the language of birds; and there is a tradition, that many volumes now extant in the Turkish language are ascribed to him. But, Solomon was not the first student of this lovely page of external nature, wherein God's wisdom and goodness is so marvelously revealed. From the dawn of creation, at the close of the first day's work, there were wonders over which the "Sons of God shouted for joy." The Great Architect never called into being or shaped a creature of material mould, that did not challenge the strictest scrutiny of the highest intelligences. Doubtless, Adam and Eve in their innocency in the garden, must have found many an occasion for adoring wonder and many a stimulus to delightful converse in the mysterious putting forth of the plant, as its young life developed before their eyes. The love of flowers is a part of the æsthetic nature of every individual of the race. It is born in the heart of the humblest peasant, in the wild children of the forest, as well as in the homes of taste and cultivation. It is characteristic of "The Lord's Prayer," that it is adapted to all the varied circumstances of human life, and that there is no occasion when its words are not fitting, and its petitions becoming. So is it with the love and the presence of flowers everywhere. Can you imagine an occasion

where their presence would be resented? While naturally associated with every thing that is bright and joyous, decorating the font at baptism, the Altar at Easter, and wreathing the brow of the bride, yet are their fragrance and beauty alike welcome at the bedside of the sick, and on the grave of the departed. And are they not now here welcome in the House of God? As I have said, the love of flowers is natural to us all and there is something in their companionship, awakening the better impulses of our nature, and which must have been eminently consonant with the environment of our first parents — as they walked in the garden amid myriads of flowers smiling a glad welcome to their pure spirits. He who, as we are told, walked and talked with them there, and who is supposed to have been the Son of God in human form, anticipating His incarnation, in all probability discoursed of the wisdom and goodness of God, thus wondrously manifested in these beauteous specimens of His handiwork; for, many centuries afterward, while standing on the mountain side, preaching to their descendants, He pointed to the flowers blooming at their feet, and earnestly enjoined — "Consider the lilies of the field."

Doubtless, this had formed the subject of many a discourse with these pure and gifted beings, whose souls, created in the image of God, were illuminated to take in the lessons which the adornments of Eden in their wonderful variety and beauty presented to their vision. And alas! when by transgression they had forfeited all right to such association and teaching, what a contrast, when they passed out into a cheerless world, where briers and thorns abounded.

Milton, in his poetic fervor, has thus given voice to the despondent Eve,

> "Must I leave thee Paradise,
> O Flowers,
> That never will in other climates grow,
> * * * which I bred up with tender hands,
> From the first opening bud, and gave ye names,
> Who now shall rear ye to the sun, or rank your tribes?"

In the imagination of the poet, it was our first mother, who gave names to the flowers, classified them in families, and ranked their tribes.

Having already quoted from the words of our Lord in His Sermon on the Mount, I cannot pass them without a few words of farther comment —

"Consider the lilies of the field how they grow."

The meaning in the original is intense. I give it from the Lexicon — "*Consider*," "*Note accurately*," "*Learn thoroughly*." "How," "in what manner," or in other words, by what law do they grow.

Here, the great teacher calls the special attention of his hearers to the hidden mystery of their life and growth. These flowers were not senseless forms of dead matter. They were living things. Life was associated with their being, and what was characteristic of life, the mystery of growth. It was not enough that His hearers should indulge their taste for the beautiful, by a hasty glance, without discrimination as to the characteristics of each separate plant. The lilies in the fields of Palestine, are described as growing in rich profusion, and with a vivid golden brilliancy in autumn, aptly suggesting the comparison of a fitting array, "with Solomon in all his glory." But this was not with the Great Teacher the point of attraction. He calls them to "note accurately how they grow." There was a hidden mystery in the growth of these living things, well deserving their careful study, and well fitted to illustrate the skill, wisdom, and goodness of Him, "who maketh the grass to grow upon the mountains."

I could honestly, brethren, fairly interpreting to my own mind their meaning, make these words an authoritative text for commending the study of Botany. Nor do I know a branch of science which, to the devout student, is so full of startling and convincing demonstrations of the wisdom and goodness of the First Great Cause of All. I cannot conceive that a scientist in this branch of study can be an agnostic, when the marvelous wisdom of the Designer and

the exquisite skill of the Architect sparkle in every shrub that grows, and every flower that blooms.

Since the invention of the microscope, which only reaches back a little more than a century, there has been a marvelous advance in botanical investigations; developing wonders of which the older students never dreamed. In the structure of the plant; in its physiological organization; tracing the nature, position and adaptation of its several members, and the purposes they subserve; as these have been studied, ascertained and settled, there have been revelations of creative skill, and such evidences of beneficent arrangement, that no devout student can withhold the grateful confession — "How manifold are Thy works, in wisdom hast Thou made them all." As without the aid of the telescope, the wonders of the heavenly bodies were but imperfectly revealed, and their intricate, unceasing, and never varying movements but partially apprehended: so, in the case of each individual plant, the naked eye could but imperfectly discern its several members; separate their constituent parts; follow their intricate connections, and diagnose the purposes they were designed to subserve: so it was not until the magnifying power of the microscope was brought to bear upon it, that many an organ was discovered and analyzed whose functions are all important to its life, and whose adaptation and workings, depending upon minute inspection, were hidden entirely from view.

There is one indisputable fact which stands out in bold relief as the outcome of the investigations of botanists of a comparatively late date; and that is the almost imperceptible boundary between the vegetable and animal kingdom. There is an analogy which admits of no contradiction, between the several members of different families in each kingdom; as to their comparative structure; the law of their physiology and the adaptation and offices of their respective organs. As an illustrution of this truth, I desire to quote from an introductory address, of the late

YUCCA GLORIOSA.

Dr. Chas. A. Pope, delivered before a medical college in this city, A. D. 1855.

"Unity and simplicity characterize the works of the Creator." Mark he does not say the works of nature, but "the works of the Creator," he believed in a personal God. He proceeds: "They obtain alike in the vegetable and animal kingdom. The simple leaf by its morphological changes, constitutes the calyx, the petals, stamens, pistil, which having diverse forms and functions according to their position on the axis of the plant, may be compared to the homologous organs of animals; *i. e.*, an organ fundamentally the same, develops in one case as a leaf, in another as a petal, in another as a stamen, or pistil; just as the arm of a man, the foreleg of a quadruped, the wing of a bird, and the pectoral fin of a fish represent one and the same organ. In vegetable as in animal growth, one great thought underlies the whole structure. The thought has in it an element of infinity, but the mode of expression is necessarily finite. And what does it indicate, but that the same word which created the plant, is expressed in the plant." God's works are every where characterized by unity and simplicity; and His forming hand is as plainly visible in the structure of the simplest plant, in the careful provision for its organs of reproduction and their potential working, as in the glittering array of the starry heavens, or the movements of the myriad planets in their appointed orbs. The laws which govern the universe know no limitation of time or space; and are not measured by the boundaries which either the microscope or telescope can survey.

We often speak in our self-complacency of this world, as formed for the use and pleasure of man, and seem to take it for granted, when in its several stages, we are told the Creator pronounced it "very good," that it was all for the sake of him who was to come forth in the last era, as the finished specimen of His handiwork.

Doubtless, he was greatly honored, when God said:

"Let us make man in our image, after our likeness; and let them have dominion over the fish of the sea, and over the fowls of the air, and over the cattle, and over all the earth." "Behold I have given you every herb bearing seed, * * * and every tree in the which is the fruit of a tree yielding seed, to you it shall be for meat." Truly a most gracious provision! but it does not follow, that because God saw fit thus to care for and honor man; that the earth was for his sole and exclusive benefit. We may well ask, amid the countless creatures called into being by His almighty fiat: "What is man that Thou art mindful of him, or the son of man that Thou visitest him?"

In the heavenly vision, vouchsafed to St. John, this was the ascription of praise addressed to Him that sitteth on the throne. "Thou art worthy, O Lord, to receive glory and honor and power—for Thou hast created all things and for Thy pleasure, they are and were created." There is a grand truth embodied in these words, which unveils, if I may so say, incidentally one of the moving purposes of the creation. The universe was called into being, doubtless because the Allwise and the Almighty willed it. It were as idle as presumptuous, to question His purposes, or to attempt to solve the mysteries, which at any time and in any direction, call forth the exertion of His almighty power. But, in this divinely inspired ascription of praise, there is the recognition of the mysterious truth, that in the infinite variety of objects called into being by His almighty fiat He was pleased to consult His own pleasure and to find delight in the work of His own hand. And this thought, if I may so express it, brings us into reverent fellowship with the Deity. This world out of the myriad worlds was not alone for man. Ages upon ages it existed; and the forests overspread the earth, and the fruits ripened, and animals roved at large, and the waters were alive with living creatures, myriads of years before man appeared. During these long periods of time, he who was created in the image of God, was as yet unborn. For whom then

was this display of the wisdom and goodness of God? Did the flowers smile and spread forth their varied tints of loveliness and beauty in vain? Did the birds chant their hymns of praise to the empty air? Was there no heart or mind in the universe to respond to the face of beauty and the voice of melody? "For Thy pleasure, they are and were created." At each epoch of the creation, God saw "that it was good," and in each and all, there was a complacent satisfaction ministering delight to the Divine Mind, in setting forth the Divine Glory. It has been fittingly observed by a late writer; "Beauty, essential beauty, belongs only to God." From this essential beauty of the Divine Nature have emanated all those forms, colors, combinations of light and shadow, which captivate the eye, and entrance the imagination; earth, air, the very caves bear witness to their essential beauty existing in the mind of the Creator and directing His works. In the words of the late Canon Kingsley. "He delights to employ His almighty power in producing ever fresh shapes of beauty, seemingly unnecessary, seemingly superfluous, seemingly created for the sake of their beauty alone — in order that the Lord may delight Himself in His works." Hence the apothegm, "A thing of beauty is a joy forever," may well apply to Him, of whose nature it forms an essential attribute; and in the exercise of which, there must ever be an unfailing source of delight. He needed not the expression of praise from the creatures of His own hand. Nor need it be a matter of surprise, that in the wide world through which man is scattered, there are unmeasured spaces and hidden regions, over which his feet have never trod, where the brightest flowers are blooming, the sweetest fruits are ripening, and Nature is clothed in her loveliest garb.

> "Full many a gem of purest ray serene
> The dark unfathomed caves of ocean bear,
> Full many a flower is born to blush unseen
> And waste its sweetness on the desert air."

But are they hid? Do they sparkle and blush unseen? There is ever an eye upon them that delights in their beauty — for, in the dark, unfathomed caves of ocean, or in the loneliness of the desert, each gem is as perfect in its conformation, each plant as complete in all the marvelous details of its growth, as when blooming on the cultivated parterre or glittering in the halls of fashion. God's workmanship is perfect in all its parts, and therein He teaches man a most important lesson.

It is said of the old architects, in planning their cathedrals, that they were as conscientious in devising and carrying out the details of their buildings, in the parts that were hidden from observation, as in the most prominent features of their work. And the reason assigned was, that the temple was built for the honor of God, and that no portion was hid from the All-seeing eye. The most trivial imperfection of the carving, the least want of honesty in the genuineness of the material, were open to the inspection of Him "with whom the darkness and light are both alike." And so, they were moved to build for the pleasure of God; and believed that the Great Architect would look with complacency upon their work.

Let me remark in conclusion — while I have ventured to argue that this beautiful world was not primarily or exclusively designed for man; yet, if we accept the teachings of the Word of Inspiration, we shall find throughout its every page, that God is a loving father, and that no created being is left without watchful care and bounteous provision. I believe, not only in an Almighty Creator, but in a special superintending providence; that the flower blooms where God has planted it; "God giveth it a body as it hath pleased him, and to every seed his own body;" that the fruit ripens when and where He chooses; that there is no waste, and no lack on the earth's broad surface; nor can time or space exhaust the never-failing supply. In the truthful and poetic language of the one hundred and fourth Psalm: "He sendeth the springs

into the rivers, which run among the hills. All the beasts of the field drink thereof, and the wild asses quench their thirst. Beside them shall the fowls of the air have their habitation and sing among the branches. He bringeth forth grass for the cattle and green herbs for the service of man. That He may bring food out of the earth, and wine that maketh glad the heart of man, and oil to make him a cheerful countenance, and bread to strengthen man's heart. * * * Man goeth forth to his work, and to his labor until the evening."

By the law of man's being he is "to earn his bread by the sweat of his brow," — and yet, with lavish hand has the Bountiful Provider scattered His gifts. This beautiful world is ours; ours to enjoy and ours to improve, by all the lessons God is daily teaching; ministering to, and developing our complex nature in its present environment, and thus fitting us, through the tuition of the world that now is, for the higher state of existence when this corruption must put on incorruption, and this mortal must put on immortality.

"Then how should man rejoicing in his God
Delight in His perfections, shadowed forth
In every little flower and blade of grass!
Each opening bud, and care perfected seed
Is as a page, where we may read of God."

PROCEEDINGS AT THE SECOND ANNUAL BANQUET.

GIVEN BY THE TRUSTEES OF THE GARDEN, MAY 21, 1891.

The Trustees of the Garden and their guests assembled at the Mercantile Club on the evening of the 21st of May, 1891, for their second annual banquet, in accordance with the provisions of Mr. Shaw's will. The gathering included about 85 gentlemen, among whom were: —

Hon. John W. Noble,
Secretary of the Interior.

Professor J. C. Branner,
State Geologist of Arkansas, and
Professor in the Leland
Stanford Junior University.

Professor D. H. Campbell,
of the Leland Stanford
Junior University.

Levi Chubbuck,
Secretary of Missouri State
Board of Agriculture.

Professor J. M. Coulter,
President of the Indiana
State University.

Professor George Lawson,
Secretary for Agriculture of
Nova Scotia, and Professor
in Dalhousie University.

Professor C. V. Riley,
United States Entomologist.

Professor E. M. Shepard,
of Drury College.

Arthur Winslow,
State Geologist of Missouri.

Hon. S. C. Eastman,
of Concord, N. H.

Hon. W. F. Boyle.

Hon. Warwick Hough,
Ex-Judge of the Supreme
Court of Missouri.

Hon. Jacob Klein,
Judge of the Circuit Court,
City of St. Louis.

Hon. R. E. Rombauer,
Judge of the St. Louis
Court of Appeals.

Judge Charles Speck.

Hon. J. H. Terry.

Hon. Amos Thayer,
U. S. District Judge.

Hon. Samuel Treat,
Ex-Judge U. S. District Court.

Gen. John D. Stevenson,
City Comptroller.

Professor M. S. Snow,
Acting Chancellor of
Washington University.

Professors E. A. Engler,
J. K. Hosmer,
W. B. Potter,
S. Waterhouse, and
C. M. Woodward,
Of the same institution.

YUCCA ALOIFOLIA (*a*) AND Y. GLORIOSA (*b*).

Dr. W. G. Hammond,
Dean of the St. Louis Law School.

Professor H. C. Ives,
Director of the St. Louis Art School.

Professor J. W. Fairbanks,
Principal of Smith Academy.

Horace Kephart,
Librarian of the Mercantile Library of St. Louis.

Judge J. H. Lightner, and

Mr. Henry C. Haarstick,
Commissioners of Tower Grove Park.

Rev. J. C. Learned,
Rev. Geo. E. Martin,
Rev. John Mathews,
Rev. Samuel Sale,
Rev. John Snyder,
Rev. H. A. Stimson,
Prof. Denham Arnold,
Mr. George I. Barnett,
Dr. G. Baumgarten,
Mr. Given Campbell,
Mr. J. G. Chapman,
Hon. S. W. Cobb,
Hon. N. J. Colman,
Mr. H. W. Eliot,
Mr. G. F. Filley,
Professor A. F. Fleet,
Mr. C. S. Greeley,
Mr. W. A. Hargadine,
Mr. E. A. Hitchcock,
Col. W. E. Hughes,
Mr. F. N. Judson,
Mr. C. H. Ledlie,
Mr. E. H. Linley,
Mr. Alvah Mansur,
Mr. I. M. Mason,
Mr. Charles Nagel,
Hon. F. J. Niedringhaus,
Mr. J. J. O'Fallon,
Mr. J. C. Orrick,
Mr. Charles Parsons,
Mr. Julius Pitzman,
Mr. A. F. Shapleigh,
Mr. W. H. Thomson,
Mr. J. A. Waterworth,
Mr. O. B. Wheeler,
of St. Louis.
Mr. Henry Hitchcock,
Mr. R. J. Lackland,
Mr. C. F. Miller,
Professor F. E. Nipher,
Mr. W. H. H. Pettus,
Rt. Rev. D. S. Tuttle, and
Mr. James E. Yeatman,
Trustees,
Mr. A. D. Cunningham,
Secretary of the Board of Trustees, and
William Trelease,
Director, of the Missouri Botanical Garden.

Coffee having been served, the Chairman, the Right Reverend Daniel S. Tuttle, welcomed the guests, and proposed the toast of the evening, in the following words:—

Gentlemen: The Board of Trustees of the Missouri Botanical Garden, in their kindness of heart and rashness of confidence if not in their wisdom, have asked me to take the chair to-night. And therefore I have the honor on behalf of the Board to extend to you, citizens of St. Louis and guests who honor us with your presence, cordial greeting and a very warm welcome. It was the desire of the

late Mr. Shaw, and he took pains to provide in his will for the practical carrying out of this desire, that there should be a gathering once a year, on such an occasion as this, of literary and scientific men, and friends and patrons of natural science. This provision of the will comes among the later ones, and I take it that in that word natural science, in speaking of the friends and patrons of natural science, and in desiring to gather together literary and scientific men, we have the key-note of what he wished to do in providing so munificently as he did for the Missouri Botanical Garden.—Not that he desired, at all, I take it, to shut away the thought that he could provide innocent recreation in the way of the Garden and flowers, and a place for retirement and a pleasant retreat for the better-to-do citizens of this city and the poorer of this city; not but what he had that in view, and that is one blessing, truly, of the Botanical Garden, the flowers that are there. It is one blessing for all to go there and see them and get the helpfulness from that innocent recreation of seeing the beautiful flowers. If we might change Shakespere a bit (we never ought to do that, ought we?)—putting "woman" for "man" and taking his well-known lines, we would say that the woman "who hath no love for" flowers, or for their fragrance and beauty, "in her soul, and is not moved by" their beauty, "is fit for treason, stratagems and spoils." And I take it that, in reading the Tale of Two Cities by Dickens, you never found in the cottage window of Madame Defarge, any flowers. And I rather imagine, if you had gone to Mr. and Mrs. Parsons' window, two or three years ago, before Mr. Parsons was taken vigorously out of this life for the good of the community, you would not have found any flowers in Mrs. Parsons' window. The people who are plotting conspiracy, as Madame Defarge did, and plotting anarchy, as perhaps Mr. and Mrs. Parsons of Chicago did, are not the ones that have flowers. Flowers are, in the first place, a great help and a blessed help to the community.—But I do not think that Mr. Shaw

had this entirely in mind, or he would not have put in this clause of his will this reference to natural science. He looked further, and saw how the establishment of the Garden and the sustentation of the botanical bureau or chair at Washington University could help in two great directions: first, by helping the agricultural department of our own country in providing for botanical investigations and so providing for the development of our agricultural resources; and, further than that, in providing leisure and men of learned leisure who could here in St. Louis help the rest of the scientific men in the world in promoting the investigations which go to make up the civilization and the progress of this nineteenth century. Let us honor his memory then in remembering that for these three reasons, — for innocent recreation, for a sort of helpful foundation lessons for the promotion of the best interests of the country, and for affording to men of learned leisure opportunity to continue investigations in the field of botanical science, — he has left this munificent benefaction for us here in St. Louis.

Then, if a man is unselfish, if a man is really unselfish, — my brother and I [referring to Dr. Lawson on his right] and a few of the rest of us studied Latin and Greek in old times, and now we go off to the field of agriculture or off in the direction of preaching, and we do not remember either, but I think the old Latin verse was — "*Serit arbores quae prosint alteri saeclo*" — he plants trees now that are to benefit the next generation, and the next and the next. If a man is unselfish and a benefactor who does that, and if a man is that who makes two blades of grass grow where one did before, surely a double, and a treble and a fourfold benefactor, in the planting of trees to benefit future generations, in the planting of this school of botanical science to benefit future generations, has Mr. Shaw been to us the citizens of St. Louis, and to our nation, and we might say to the cause of science throughout the whole world. And therefore, may I not feel that I am

only a voice giving expression to the determination in the hearts of us all that we will, please God, year by year, come up to this feast with a determination to keep it in such a way as to manifest our warm gratitude for the useful and munificent life that the founder of the Garden lived in this city of his adoption, and to show cordial honor to his cherished memory?

It becomes my privilege to propose directly the one toast of the evening, and I take the liberty to call upon one of our citizens to respond to that toast afterwards, Professor Waterhouse of Washington University; one who, so far as I understand,— and you must remember that I am a new comer in St. Louis, and must pick up the best I can, little notes and thoughts of what took place before I came here — one who, I think, was personally acquainted in earlier years with Mr. Shaw. And perhaps some thoughtful suggestions of my brother who is to speak to you, lodged as seeds in the already fertile and ready soil of Mr. Shaw's thoughts with regard to establishing the botanical chair in Washington University, and preparing for this consummation that we have now in the Missouri Botanical Garden.

Gentlemen and friends, I have the honor to propose to you,— and may I remark that if you will look in front of you you will find in your glasses some of Mr. Henry Shaw's Port that has been brought here,— I have the honor to propose to you the toast of the evening, — The Memory of Henry Shaw.

Professor Waterhouse responded as follows:—

At Agra, in central India, there is perhaps the finest park in the world. It is small, but surpassingly beautiful. Laid out with exquisite taste, embellished with numerous fountains, rich with the varied bloom of a tropic luxuriance, and populous with birds of a plumage so brilliant that they look like winged gems flitting through the foliage, it realizes the classical idea of a paradise. The grounds

YUCCA ANGUSTIFOLIA.

form the approach to the Taj Mahal, a temple-mausoleum whose faultless symmetry and almost celestial beauty complete the picturesque loveliness of the scene.

The Indian park was founded by an emperor — the Missouri Botanical Garden was established by a private citizen. The former was dedicated to the memory of an empress — the latter was devoted to the refinement of the people. The first was reserved, under native sway, for the exclusive gratification of the nobility — the second was freely opened to the enjoyment of all classes. With the resources of a realm at his disposal, the emperor of India lavished four million dollars of the public treasure upon the splendid memorial of a private sorrow — from the means of a self-acquired fortune, our American benefactor gave five million dollars for the elevation of mankind.

These contrasts illustrate important differences between despotic and republican institutions. In all ages, irresponsible power has developed patrician selfishness, but popular government fosters public spirit.

The benefactor whose memory we to-night revere was endowed with a nature which the liberalizing influences of free institutions easily disposed to acts of philanthropy.

Henry Shaw was happy in the gifts of fortune. A robust constitution, strong sense, and the incentive of limited means assured success. At the early age of nineteen, Mr. Shaw began his mercantile career. The business, commenced under the humblest conditions, and conducted under the sole management of an inexperienced youth, was prosperous from the outset. His success may be taken as the measure of the ability by which it was won. In twenty years, the thrifty merchant acquired a fortune of a quarter of a million. Then, in the very prime of his manhood and at the height of his commercial prosperity, Mr. Shaw withdrew from business. This was an instance of self-control as rare as it was wise — an example of self-restraint which few merchants who have known the pleasures of accumulation have been able to imitate. But

Mr. Shaw did not propose to devote his whole life to mere money-making. He had higher aspirations. His retirement from business afforded leisure for reading, foreign travel, and studious observation. His improvement of every opportunity for self-culture did much to supply the deficiencies of his early education.

But it is not for his scholarly attainments, nor yet for his sterling integrity and unaffected simplicity of character, that this community chiefly cherishes the memory of Henry Shaw. His distinctive and highest title to our gratitude is his princely munificence to St. Louis.

Mr. Shaw was imbued with a strong love of nature. It was the delight of his earliest years

> "To revel in life's springtide glow
> Of sun and flowers."

To his passionate fondness for floral beauty, the Botanical Garden, Tower Grove Park, and the School of Botany owe their origin; and to his nobly unselfish desire to admit his fellow-citizens to a participation in enjoyments which he so highly prized, is to be ascribed the transfer of his flower-grounds to the city. He distinctly recognized the importance of public resorts where every object will cultivate and gratify a refined taste.

In the comprehensive School of Botany which Mr. Shaw established, the course of study is not restricted to the known facts of botanical science, but ample provision is made for original investigation. Mr. Shaw fully appreciated the economic importance of applied botany, and sought to extend the bounds of scientific discovery. In every land, able investigators are now studying the problems of practical botany. The future is full of brilliant possibilities. Successful endeavors to improve the variety and beauty of plants, to preserve trees and timber, to arrest the ravages of insects, to ascertain the food, habits, and medicinal virtues of plants, to naturalize useful exotics, to define the processes and laws of vegetable growth, and to

explore the interrelations of plant and insect, would increase the resources and happiness of mankind. The prevention of animal and vegetable disease would save this country tens of millions every year by the preservation of its cattle, fruits, and cereals. The complete attainment of these objects is perhaps impossible, but it is confidently believed that the Shaw School of Botany will do its full share in their particular accomplishment.

But its founder did not limit investigation to purely utilitarian researches. His purposes were broader. He sought to cultivate, by study in the School and observation in the Garden, an intelligent appreciation of the loveliness and wondrous mechanism of flowers. He believed that communion with the fairest offspring of nature and an enlightened perception of the infinitely varied charms of floral form, tint, and fragrance would uplift the soul to loftier contemplations, and inspire a thoughtful reverence for Him who provided all this beauty for human enjoyment.

The School which Mr. Shaw founded will make St. Louis one of the great centers of botanical research, and largely increase the usefulness of Washington University. Every friend of liberal learning will be deeply grateful for the endowment of so important a department of the University.

It is for these great services in behalf of a higher civilization that we to-night honor the memory of Henry Shaw. But neither the benefits of his generosity, nor the obligations of public gratitude will be confined to the present generation. Distant ages, equally sharing his bounty, will bless the benefactor who provided for them such beautiful pleasure-grounds for refined enjoyment, and such ample facilities for scientific study.

Mr. Shaw built his own monument. His benefactions are memorials as enduring as our civilization. Marble and bronze will crumble, but an organized and well endowed beneficence is immortal. Surviving the ever-changing recipients of its benefits, it finds a fit emblem of its

imperishable usefulness in those ever-living forces of nature which work the annually recurring miracles of leaf and blossom.

Mr. Shaw's example is an incentive to emulation. It teaches youth that

> "The ripening soul should ever yearn
> For something higher —
> Should for its noblest interests burn
> And thus aspire;
> Should, with the powers of manhood's prime,
> The rugged hills of knowledge climb,
> Where, from the towering steeps sublime,
> The soul may view
> The flowers and fruits of well-spent time,
> Forever new."

The Chairman then called upon the Honorable John W. Noble, Secretary of the Interior, who responded in some well chosen remarks, closing in the following words: —

To-day I walked a few moments with some of your Trustees, among the trees of the Park. It has been my privilege as Secretary to take care of some of the trees of the United States. I have had an opportunity given me to say that the *Sequoia gigantea* shall no longer be ravaged by the herder nor consumed by the fire of the man that wants to make a camp regardless of those wonders of the world that future generations ought to be allowed to admire. And I was complimented a few days ago by a no less distinguished gentleman than Murat Halstead saying, "When you ordered the cavalry, Noble, around the trunks of those great old trees you made a reputation for yourself that your learning as a lawyer" (that was a pretty big draft on the imagination!) "or in any other particular will never begin to attain." It was my privilege to advise with the President and with his coöperation to add, I will say, almost twenty thousand square miles to Yellowstone Park, that the trees there might preserve the sources of our rivers and fertilize our plains. It is my purpose, if I can, to have this ground

FROM GARDEN AND FOREST.

YUCCA ELATA.

so guarded by force that the grand flora of the United States, there springing as high as the head of a man on horseback, may once more bloom and not be made the herbage for the sheep from Mexico. I propose, in the spirit that I felt this afternoon when walking beneath the shade of the old Garden, to gain some inspiration for myself, if I must be an officer, from that man's soul who here said, as has been so eloquently alluded to by both the speakers this evening, "I want to educate mankind in the nature of the trees, the wonderful resources of the flowers of the earth, and I want them to cultivate them as the friends God gave them to have for their good. Do not waste them. Do not let the saw and the woodman's axe cut down all of them until your plains become deserts, but say, in all these great regions we will preserve, in recognition of that divine hand that made them, these the friends of our human family." And I thought another thing. I am not, I believe, in your estimation, a very devotional man; but it did seem to me as I walked among those flowers and those beautiful trees in Shaw's Garden that if in that other land there is a place of beauty where the sun ever shines and the flowers ever bloom, the paths through which this great man shall pass will be the brightest from the bloom and the sweetest from the fragrance, of those trodden by any man that has gone from among us to that greater realm.

Professor George Lawson, of Dalhousie University, the Secretary for Agriculture of Nova Scotia, then responded to a call from the Chair, his remarks including the following: —

You are all more familiar than I can be with the bequest of Mr. Shaw and the circumstances attending it, and it has been very eloquently referred to here to-night. I, therefore, need not refer to that except in this way: that I regard Mr. Shaw's bequest not as a mere gift of a magnificent garden and grounds to the City of St. Louis; but I

look upon it as something of a far more important character. In reading through, which I did with great pleasure and instruction, and benefit in other ways, that remarkable will that has been published in the first annual report of the Trustees, I found that Mr. Shaw has read to the world a sermon on that subject that we have heard so much about within the last year or two, — the gospel of wealth. He has shown to the whole world in a thoroughly practical way that the preaching of this gospel is not best to be done by a man writing his will and leaving a pile of money to be distributed after his death. Now Mr. Shaw took the very sensible way, and sensible from many points of view, of using his money, at a time in life when he could enjoy the using of it. I am not going to repeat what has been said; but what is the use of money? What is the use of money? I will not appeal to commercial men, to business men, but I appeal to my own class of people, to every botanist and scientific man here to-night; and I know how they all feel about it. What is the use of money unless it can be used? Now Mr. Shaw perceived this. Mr. Shaw, after he accumulated his money, stopped. He said, "Now I have got the money, I will not leave it in the bank, but I will use it. I cannot use it for myself. I cannot wear any more clothes than any other man. I cannot eat any more, or drink any more, or smoke any more, or read any more, or look at pictures any more than another man; but I can do what is far better. Far better than using this money for my own personal gratification, I can use it for giving pleasure to others." And the highest pleasure!

Mr. Shaw has given this lesson to the world: that the proper way to use wealth and the real gospel of wealth is to begin to use it at a time when one can get back the reflex pleasure from the enjoyment of others, and to plan for its good use to continue hereafter. Mr. Shaw did this in a signal manner. When a man dies and leaves his money and leaves it without too much thought, perhaps, he does not consider what Mr. Shaw seems to have so well con-

sidered, — and I speak of him without knowing a single thing about the man but what I have heard here to-night and what I have seen in your report. He provided for those who had contributed to his comfort in this life; provided for those who had given him pleasure; contributed to their pleasure in return; contributed to the various charities in your city, the various bodies who are grappling with poverty, with the various forms of human misery that in all large cities prevails and which so often needs the help of those who have means. He thus discharged his duty to those around him, — to his neighbor. And then, with the residue, he does what? He provides for all time a garden for this great city of St. Louis, a garden where rich and poor alike may come and enjoy its flowers, the only pleasure, as I was reminded to-night by one of the speeches, the only pleasure, as an old French writer has said, that increases instead of decreasing with age. He has done that for you citizens, but he has done more than that. And that is the reason I am here to-night. If it had been simply to do honor to Mr. Shaw for contributing to the elegance, to the comfort, to the benefit of this city, I would hardly have felt that I had an apology for appearing among you. But Mr. Shaw has done two things. He has established a school of botany, a school for the education of gardeners, — than which nothing, I might say, was more needed on this continent. We go to France and Germany and England and to different European countries, and we see the magnificent gardens that exist there. How is it that these gardens are kept in such admirable order, that there is so much skill, so much art, nay more, so much science displayed in the laying out and the management of those gardens? Because there is there, growing up year by year, a large army of professional gardeners. Where is there on this continent — where has there been in the great United States of America, or in the northern British Provinces which we now call the Dominion of Canada — where is there a school for gardening, a means of training

gardeners to the work of gardening in its proper sense? This continent has been without it, and Mr. Shaw has been the first to recognize — not the first to discover the fact, but the first to recognize in a practical way — the want and to supply the deficiency. Mr. Shaw, then, I think has done signal service to a very important class, an important portion of the working class of this American continent, and has shown an example to the other States of the Union and to your neighbors on the north, in the country from which I come.

But the benefits that Mr. Shaw has conferred do not end here. He has provided for the ample prosecution of scientific research. He has established in your Washington University, as I understand, a chair of Botany. He has provided that Botany should be a science always taught in the city of St. Louis in your University. Botanists may claim, I may say, to be the most grateful of all men, on this account. And the botanists, not only in this State or in this country, but the botanists of the whole world recognize in an act like this that a service has been done to Science — a service of a permanent kind that they will never fail to remember.

I must not close without making one remark, and saying in that connection, that if Professor Trelease were not here I would speak more freely; but I would say to you, gentlemen Trustees, that I think you have been exceedingly fortunate in securing your executive officer. As I have said, I only met him last night for the first time, but botanists understand each other, and in the course of my life I have often been asked to advise as to the appointments in connection with botanical gardens and universities and putting up university buildings and so on, and I must say that I was charmed not only with the Garden, but with the thorough, systematic manner in which it was being carried on. Not that I have anything to say as to Professor Trelease's scientific merits; for they are known to the world. But it is very rare, as

many of you know, it is not by any means common but I would rather say very rare, to find a thoroughly equipped scientific man, a man with thorough scientific knowledge, able to uphold his own in the scientific world, and at the same time to have that systematic business capacity that enables him to carry out successfully a great work such as you Trustees, gentlemen, have upon your hands. I feel that, with Professor Trelease as your executive officer, you have every prospect of great success in the future.

And now I will only say in conclusion that I appear here not merely in my personal capacity. If it had been a mere personal matter I might not have felt that I had a right to come before you and say what I am going to say; but as one who did a great deal of botanical work in the old world in connection with the Edinburgh University, and the Botanical Garden there, and in later years in the Canadian provinces both in Nova Scotia and Ontario. I feel that from my connection with many of the botanists of Canada who have done useful work of late years I may safely venture to express not only my own thanks but their gratitude to you gentlemen for carrying out the purposes of Mr. Shaw in such a thoroughly public-spirited manner and in inviting even from far away Nova Scotia as one of your guests an inhabitant of a remote province to come and see how the work is being done. That is an earnest to me of the future: — that these annual meetings themselves, which Mr. Shaw looked forward to, may be made the center, may be made the rallying point, that St. Louis may be made the rallying point as it were for the botanists not only of the American continent but of the rest of the world. And I feel sure that wherever your annual report goes, wherever a real knowledge of the Shaw Botanical Garden and the Shaw School of Botany and the work that has been done here shall penetrate, you have the hearty thanks and can demand at any time the hearty co-operation of every botanist of Europe and America.

On the conclusion of Dr. Lawson's address, the Chairman introduced Mr. Given Campbell, of St. Louis, who spoke appreciatively of Mr. Shaw and his great work for the city of his adoption.

Letters of regret were presented from invited guests who had been unable to attend, among whom were Professor E. D. Cope, Editor of the *American Naturalist*, President O. Clute, of the Michigan Agricultural College, Mr. G. Browne Goode, Director of the National Museum, Professor James Hall, Director of the State Museum of New York, Professor W. T. Harris, United States Commissioner of Education, Professor E. S. Holden, Director of the Lick Observatory, Professor C. H. Peck, State Botanist of New York, Dr. E. Lewis Sturtevant, formerly Director of the New York State Agricultural Experiment Station, Hon. Edwin Willits, Assistant Secretary of Agriculture, and other distinguished scientists. The Chairman then introduced Professor C. V. Riley, Entomologist of the United States Department of Agriculture, who spoke as follows: —

Mr. Chairman and Gentlemen: — I had hoped not to be called upon. I esteem it a privilege and honor to be with you to-night, but thoughts crowd so thickly on such an occasion that it is impossible to do them justice in condensed utterance. Time wings its even course so swiftly, from the retrospect, that it is hard for me to realize that over two decades have passed since I first became intimate with him whose memory and beneficent deeds we meet to commemorate.

In my early St. Louis days I was drawn both by taste and occupation, into the company of men who were generally my elders, and it was my good fortune to become intimate with many who have made this community and the whole country the better for having lived in them. Engelmann, Spencer, Wislizenus, Baumgarten, Shumard, Holmes, Shaw — not to mention those yet living here — will thus

YUCCA FILAMENTOSA.

remain with me in spirit and influence as long as memory shall endure. Henry Shaw held a unique position among these. He was a lover of Nature; not a special devotee of Science. Yet he was so alive to the welfare of the plants in his garden and park that everything pertaining thereto interested him. And thus it came about that I was often consulted and spent many a pleasant and profitable hour with him who was by nature rather reserved.

It were supererogation at this time to praise the substantial work which he did for St. Louis, for the country — aye, for the world, — where others who knew him better have already so fittingly done so. But there were three characteristics of his life which shone forth from his other peculiarities, and which those who gather at these annual banquets should never tire of emphasizing. These were his sturdy sense of honor and strict business integrity, his estimate of wealth as but a means to a noble end, and his strong love of Nature.

No nation can achieve the highest endeavor and development that does not recognize its own weaknesses and endeavor to overcome them; and are we not in need, as a people, of enforcing on every possible occasion those principles which Shaw's life exemplified? Had he not seen corruption in municipal, state and federal legislation too often fattening on loose public sentiment; dishonesty winked at as smartness, if only successful in its avaricious aim? Had he not seen how, too often, our most industrious and successful men had wrecked health and happiness in devotion to business which became a passion for mere lucre, until it shut from their lives all other avenues of enjoyment, stunted the intellectual and moral nature, and left to sons, in accumulated wealth, a heritage of questionable value? Had he not witnessed the rapid increase of money kings, the concentrating of vast wealth in the hands of the few and the growth of trusts and monopolies at the expense of the toiling masses, until socialism in some of its more hideous forms began to lift its head in the land? Had he not, in short,

felt that there is danger in our material growth, unparalleled in the history of the world, unless guided and influenced by something higher and more enduring, which will save us from the fate so graphically portrayed in Byron's well-known lines:

> "There is a moral to all human tales;
> 'Tis but the same rehearsal of the past.
> First freedom, and then glory — when that fails,
> Wealth, vice, corruption — barbarism at last,
> And history, with all her volumes vast,
> Hath but one page!"

Henry Shaw knew the refining, elevating and broadening influence of the study of Nature in her more pleasing manifestations. He drew inspiration from the voiceless lips of flowers, and appreciated the value and need of these same influences to the community at large.

The Missouri Botanical Garden and the subsidiary School of Botany give St. Louis proud preëminence in matters which all good citizens must appreciate. The older botanic garden and arboretum at Cambridge do not excel it and nothing else approaches it on the continent. The national botanic garden at Washington is, as such, a farce and a disgrace. Its chief function seems to be to furnish bouquets and plants to congressmen and their friends, and its influence has so far been destructive — not helpful — of all effort looking to the establishment of a truly national and creditable garden. This Missouri garden and school will prove a material and perpetual monument to Shaw's practical wisdom. But valuable as they are and will ever be, I doubt whether they will have more enduring or important influence on the country at large than the lesson of his life as manifested in the three characteristics which I have indicated; and it seems to me that it must have been a patriotic and underlying sense of this fact which prompted, as much as anything else, the provision for these annual feasts. His work had otherwise insured the keeping of his memory as fresh and green as the May foliage he loved so well —

had already made it certain that due homage would be awarded "till the last syllable of time recorded."

Gentlemen, as an old St. Louisan I feel proud of what Mr. Shaw did. St. Louis is to be congratulated on having had such a citizen; she is to be congratulated that he chose as first director of the garden, one so well qualified for the work. I have watched Prof. Trelease since his graduation from Cornell and have been in close working contact with him, and I but echo the sentiment of all who have had the pleasure of his acquaintance in expressing the confidence that he possesses in a marked degree the knowledge, the enthusiasm, the devotion, the tact and the ability to build wisely and for the world's benefit on the munificent trust with which he has been charged. Gentlemen, I thank you.

Following Professor Riley, the chairman called upon Hon. F. J. Niedringhaus, who spoke entertainingly for five minutes, after which Professor J. M. Coulter, President of the Indiana State University, was presented, and concluded the speeches of the evening, as follows:—

I came to this banquet expecting to enjoy thoroughly every moment of it. But when, after coming to this room, I was met with the statement that I would be expected to say a few words, a deep vein of sadness entered into my feelings. For it was stated that all the speeches were to be informal; and if there is one thing I cannot make it is an informal speech. I am the perfect embodiment of formality. But seriously, when the botanists of this country heard that Mr. Shaw had left his great garden for the sake of the advancement of botanical science, there were universal expressions of delight. And after that, when they understood that there had been appointed as the director a well-known and accomplished botanist, their delight was still greater, for it inspired them with great confidence in the outcome.

I suppose that there are some people yet who imagine that a botanical garden is simply for the cultivation of the æsthetic in a man, a sort of place for the propagation of nosegays. I imagine that this opinion is very widely distributed through the country. It is the only way that I can explain how it is that botanical gardens are not as numerous as universities. Now, I would like to simply make one suggestion. I would recognize in the outset the great æsthetic influence that is developed by a garden of this kind; but in the very nature of things that influence can only be local. It can only be imparted to those who are fortunate enough to be here and to visit here. Another more advanced thought was suggested and has been spoken of to-night, and that is that it is also for the study of plants from their economic stand-point, in their relations to mankind. I would like to take one step beyond that, because after all, that is only a selfish question: What can we make out of these plants for our own use? There is a great science that is clamoring for development, and that is the science of biology. There is no subject so important, or more important. There are no problems more recondite than those which pertain to the laws of life, and there is no field in which we can study or investigate the laws of life so well as in this field of botany. And therefore I would suggest that a botanical garden, beyond its æsthetic value, beyond its economic value, possesses within it that great wide range of values which appeals to the whole world around; — that it is a place for the study of the laws of life.

It is only in this way that this Missouri Botanical Garden can become world-wide in its reach. It is set here in the midst of a great flora, the North American flora, in the very heart of a flora which demands yet years and years of unremitting study. And botanists are all recognizing to-day that in order to get at any correct conception of plants we must study their life histories; we must grow those plants; we must watch them from their start to their ma-

turity. It is only in this way that we can get at any conception of the proper relations of the plant kingdom. I would, therefore, commend to you that movement which I believe is starting, that the Garden may be one in which this shall be more and more fostered, and that it shall become a place where we shall have as far as possible a complete representation of the North American flora. You can make no wiser expenditure of means than to advance this part of your work; to cultivate here all our northern plants so far as possible, and in addition to that, to add to the library and to the herbarium materials which, supplementing those growing, will make this a great depository of information, a center to which all students of North American botany must go.

I will close by speaking of a use that I have found for the Garden already. It has been put upon me to make a study of the North American cactuses. I found very speedily that the only place where I could study those cactuses was the Shaw Gardens. I found there kept the types, the work of Engelmann; and no student of North American cactuses can make a move in that study unless he lays his hand upon Doctor Engelmann's works. I also found this advantage there; that it was not only a place in which the material had been stored which had already been worked up, but I found a readiness and a willingness to receive fresh material that I proposed to send to it from a summer's Government exploration, there to be cultivated for me so that the living plants can be studied. It is the only place that I can find in this country where those plants can be properly cared for and raised to one's hand, and therefore it is with a feeling of appreciation of this Garden, an unusual feeling of appreciation, that I speak of this circumstance, for I feel that it has made this, which is of course a difficult and an extensive work, at all possible. I would, therefore, suggest to you that in this line, developing the biological side, the side of pure science, of science for its own sake, its own dear sake independent of any

economic importance to us, this Garden is to become notable. It is in this direction that the eyes of the world at large are upon it, recognizing in this a new departure in this country. You must, therefore, remember that upon that side you are the cynosure of all eyes — botanical eyes — and they shall be watching every move you make in this direction and will hail you as one of the pioneers and progenitors of this most important movement.

YUCCA WHIPPLEI.

PROCEEDINGS AT THE SECOND ANNUAL BANQUET TO GARDENERS, FLORISTS AND NURSERYMEN.

GIVEN AT THE MERCANTILE CLUB, NOVEMBER 10TH, 1891.

Under direction of the Board of Trustees of the Garden, the second annual banquet to gardeners, florists and nurserymen, was given at the Mercantile Club, on the evening of November 10th, 1891, the Director of the Garden presiding. Seventy-five plates were laid, among the guests of the evening being:—

HON. N. J. COLMAN,
Ex-Secretary of Agriculture.

HON. C. C. BELL,
of Booneville, Mo.

PROFESSOR S. A. FORBES,
State Entomologist of Illinois.

HON. CHARLES E. HAY,
of Springfield, Ill.

MR. W. A. MANDA,
of Short Hills, N. J.

MR. E. H. MICHEL,
President, and

MR. EMILE SCHRAY,
Secretary,
of the Florists' Club of St. Louis.

MR. A. NELSON,
President of the Laclede County Horticultural Society.

MR. E. A. RIEHL,
President of the Southern Illinois Horticultural Society.

MR. EDGAR SANDERS,
of Chicago, Ill.

MR. H. J. WEBBER,
Assistant, Shaw School of Botany.

MR. L. ARMSTRONG,
MR. J. H. BANNES,
MR. E. BEAUMONT,
MR. C. BRANCH,
MR. D. I. BUSHNELL,
MR. C. D. COLMAN,
MR. C. CONNON,
MR. J. F. DICKMANN,
MR. F. J. FILLMORE,
MR. H. HANFT,
MR. H. HEGEL,
MR. E. W. HICKS,
MR. J. M. HUDSON,
MR. D. JANNOPOULO,
MR. J. M. JORDAN,
MR. C. A. JUENGEL,
MR. S. KEHRMANN, JR.,
MR. J. KOENIG,
MR. C. A. KUEHN,
MR. J. W. KUNZ,
MR. E. A. MICHEL,
MR. C. W. MURTFELDT,
MR. H. OPPERMANN,
MR. F. W. OSTERTAG,
MR. H. C. OSTERTAG,
MR. ALFRED PLANT,
MR. C. E. PRUNTY,
MR. P. QUINN,
MR. H. H. RIEMAN,

Mr. Carew Sanders,
Mr. C. C. Sanders,
Mr. Wm. Schray,
Mr. J. Stocke,
Mr. J. Stocke, jr.,
Mr. R. Tesson,
Mr. George Urquhart,
Mr. A. Waldbart,
Mr. W. J. Wellhouse,
Mr. J. F. Windt,
Mr. E. Wurst, and
Mr. W. C. Young,
of St. Louis.

Chancellor W. S. Chaplin, and
Mr. D. F. Kaime,
Trustees,

Mr. A. D. Cunningham,
Secretary of the
Board of Trustees,
William Trelease,
Director,
A S. Hitchcock, and
Earl Douglass,
Botanical Assistants,
J. C. Duffey,
Horticultural Assistant,
James Gurney,
Head Gardener,
J. W. Dunford, jr.,
Garden Assistant, and
Thomas Doss,
of the Missouri
Botanical Garden.

After a short address of welcome, the Chairman proposed the toast of the evening, — to the memory of Henry Shaw, — to which Hon. Norman J. Colman responded in the following terms: —

Mr. Chairman: — While partaking of this bountiful repast, I have been thinking what was the object, the motive, or intention as you have designated it, of the late Mr. Shaw in providing for these annual reunions, for all time to come, so that those who are engaged in this profession a thousand years hence, if our institutions remain, will meet just as we are meeting at this time. I think that his motive was not to simply bring us together for the purpose of enjoying a rich repast, but that he had other and higher designs. It was not simply to perpetuate his memory, but to advance that noble cause which he had so much at heart. It is true that he knew that it was well for kindred spirits to meet, and he perhaps desired to establish that *esprit de corps* which should always exist among the members of a great profession, if we may call it such, and which, perhaps, is not existing in the force and in the strength that it ought to. Mr. Shaw undoubtedly thought that it was well to bring those engaged in these pursuits together,

that they might compare notes, consult with one another, and do what they might think best towards promoting that pursuit which he had so much at heart. And I think, if we will look to the life and history of Mr. Shaw we shall see that in all of his designs he was looking for the advancement of horticulture, and the refinement and elevation of the people.

In establishing Tower Grove Park he did a great work — a needed work at that time. I recollect well when we had scarcely a park in this city; and at the time when he first took steps towards the establishment of that park we really had but one, and that was the Lafayette Park of about thirty acres, in the southern part of our city. Numerous efforts had been made to establish a park system and to establish parks, and all of them met with failure. As long ago as the year 1854 I was a member of the Board of Aldermen, and there was a magnificent tract of land, west of the city — the Lindell estate, which some of my friends present will recollect, of several hundred acres, which could have been bought at between three and four hundred dollars an acre. Being a member of the Board I urged the passage of a bill for the purchase of that land, so near now to the very heart of our city, but the members of the City Council thought it was too far away, and I could not induce them to do it. And the City Council, up to the time that Mr. Shaw took the step towards establishing Tower Grove Park, was very backward, and in fact would do nothing towards establishing a park system. He gave his park to the public, and a sort of fever and inspiration, as it were, took possession of the people for the establishment of parks.

But it was not through the City Council, however, that our parks were obtained. Some of my older friends will recollect that we secured Forest Park, one of the largest and most magnificent in the country, from the County Court of St. Louis County, instead of the City Council, and all the bills had to be rendered to the County Court.

An act of the Legislature was passed by which two members of said Court were to act as commissioners, and two to be appointed on the part of the city, and the President of the County Court was to act as President of the Board; and the matter was conducted in that way.

The example which Mr. Shaw set in establishing Tower Grove Park led to the development of the park system in this city, and we have now a greater area of parks than any other city of the same population in the United States, if not in the world. There is not in America a larger park than Forest Park, unless it be Fairmount Park in Philadelphia; and what led to the establishment of that park was not especially the desire to have it as a park, but it was urged as a sanitary measure, to preserve in a healthful condition, in an uncontaminated state, the Schuylkill River which supplied the city of Philadelphia with water. So I think we owe to Henry Shaw a debt of gratitude for establishing a pattern, a model here, in Tower Grove Park, which led to the introduction of other parks in the city.

Likewise in establishing the Missouri Botanical Garden, he had a motive. He made there a sort of breathing place, as all parks and gardens are the lungs to a city, where the people can go and enjoy the pure country air, the songs of birds, the sight of beautiful flowers, the fine landscapes, which are everywhere presented to the view.

Mr. Shaw had an innate love for the beautiful in nature. He had been abroad. He had visited the beautiful Chatsworth Garden and the Kew Gardens and the best gardens in Europe, and it is said that he became inspired while visiting the Chatsworth Garden with the thought of establishing here the grand Missouri Botanical Garden, and Tower Grove Park, both of which have been so beneficial to the city. He was a native of England, and when he first went out to Tower Grove and erected his house he undoubtedly had in view simply the establishment of some such place as the country gentleman of England enjoys. But when he had obtained wealth and position, and when

he saw that he could leave here a monument which would endure forever, a monument which would be an ornament to the city and a blessing to its people, which would refine and elevate everybody who came in contact with it, he determined that that should be the work of his life; and that work has been most nobly done. Where can we find another such a man, with such a history, who has done so much for any city, aye, so much for any country, as Henry Shaw has done? What other city, what other state, what other nation has had a Henry Shaw, leaving so munificent a donation, leaving such a grand work for humanity? It is not simply the masculine members of the human family that enjoy it, though I know that all those of refined feelings do, but it is especially that other portion of the human family, our wives and our daughters, who will remember with gratitude and devotion the work which Henry Shaw has done for them.

Not only here in the city will his example be remembered, but by all those who visit the garden, from whatever state or nation they come. It will have a most telling and important effect throughout this whole Western country; because here is an example, a model, which many men — and I hope there may be hundreds and thousands of them — will pattern after in a limited manner, if not in greater degree. This example will be followed. It will have its influence for good. Our city does not begin to compare with many other cities in the ornamentation of private grounds and private residences. We can almost count upon the fingers of our hands the number of beautiful residences, the grounds around which have been properly laid out in landscape style. We may go to Cincinnati, to Cleveland, to Boston, to Philadelphia, to almost any other city, and find hundreds and thousands of residences with beautiful grounds about them, ornamented in the highest style of landscape gardening, but I am sorry to say they are not to be found here. I wish that I could talk to every house owner in the city of St. Louis to-night and urge upon him the

importance of following to some limited extent the example which Henry Shaw has set.

There is nothing that has a finer influence upon the family than to bring them in contact with trees, shrubs and flowers, and with everything that is beautiful and lovely in nature. There is an inborn love in man for flowers, for beautiful landscapes, for all objects of beauty; and where children are brought up within their influence, this part of their nature is developed and they are elevated by it and become better citizens.

Following Mr. Colman, the Chairman introduced Professor S. A. Forbes, State Entomologist of Illinois, who spoke as follows: —

I am used, before some audiences, and on some occasions, to speaking upon the subject of the relations of entomology to horticulture, but I confess that the situation here puzzles me. I should suppose that on an occasion like this entomology would be about the last thing that a horticulturist would care to hear about. I have a firm belief — a very well grounded suspicion, at any rate, — that if the science of entomology and the subject of that science could be swept out of existence together, you would be unanimously in favor of it.

And yet, as I look over these tables I see that after all there is another side to this question, which, perhaps, is not as common to our minds as the one that enforces itself by way of the cucumber beetle and other insects of that class; and this, in order to give me a little standing room here for the minute or two that I shall speak to you, I will call up. Has it occurred to you, as we look over the floral show upon these tables, that the very science of floriculture is due to insects? That is one of the commonplaces of modern science; that if there had been no insects, there would have been no flowers; that in fact, in a very great sense, an insect is the creator of a flower; that every flush of color upon the petal, and every driblet of honey, and

YUCCA WHIPPLEI.

every particle of floral odor wafted on the wind, — that these are the simple invitations to insects to make their fertilizing visits to flowers, without which these flowers would never have been. So I think that we as horticulturists owe a certain respect to this much berated science. I have sometimes thought that it was a wonder that every horticulturist, upon whose mind this fact had been borne, was not an entomologist also from pure gratitude, if for nothing else.

But probably it is as an economic entomologist that I have been invited to attend this meeting; and it is very likely upon the other side of the question that you will expect me to say something. And I must confess, on behalf of the favorite objects of my official existence, that they are not all of this kind; that they are not all permanent aids to agriculture. Some of them do have a vexatious habit of reaping where they do not sow, and of levying a burdensome tax upon the plant, for which they make no return. We must acknowledge that. You will not perhaps expect an essay or an address upon the subject of economic entomology here. This is not the time or the place for it. And yet there is one general idea, which it seems to me is not entirely inappropriate to the purpose of this gathering, which I would like to illustrate by a simple point or two. If we scan the various measures of defense which, as agriculturists, we use against insects, I think we shall be pleased to notice that some of the most important of them are simply applications of the methods by which plants themselves have in the long course of evolution learned to defend themselves against their enemies. For example, when you fumigate your hot houses, what do you do but to apply everywhere, and bring to bear upon every plant in the conservatory, that device, that method of defense, that chemical principle, which a single plant has learned to elaborate in its own tissues as a defense against its enemies? When you sprinkle your rose bushes with hellebore, what do you except to provide these defense-

less plants with the defense which the hellebore has learned to manufacture as a means of defense against these enemies of its own foliage?

There is another application of the same idea which is illustrated by the very latest work of our entomological laboratories. As there is a class of insects which, as we all know, live entirely upon living vegetation, the botanists now say that there is a class of plants which, on the other hand, live entirely upon living insects. The plant world has, in short, learned to retort upon the insect world. And we are learning to use these natural enemies, these plant enemies of insects, for the defense of other plants. We have learned lately for example, that one of the most deadly and destructive of these may be readily cultivated in great quantities in as simple a thing as corn meal mush, if you only make your mush with soup instead of with water. How easy a thing it would be for a horticulturist to maintain a crop of these deadly agents, so that their spores might float everywhere and settle upon any insect that would be apt to injure the vegetation! These are all evidences of the fact, which is illustrated more amply than I shall be able to illustrate it to-night, that the greatest success in attempts to accomplish our purposes with respect to natural objects is to be attained by utilizing the methods and the system and the expedients of nature, and by a more general and a wider application of those methods.

Before I take my seat I desire to express, as an entomologist, my interest in what Henry Shaw has done, and in what those who are carrying out his will are doing here: not in behalf of entomology alone, but of horticulture and agriculture, because these sciences are so related to each other that whatever improves, advances, or encourages one, improves, advances and encourages the other also. Entomology is in some senses a subordinate science. In a practical way, it shines partly by its own light and partly by a reflected light; and you may be sure that we are much interested in the sources from which this light comes,

which can be reflected back upon horticulture and agriculture to make our science as useful as it is. Whatever gives floriculture or horticulture in any of its branches useful and valuable aid and service, likewise gives a stimulus to the entomological relations of that science. I have no idea that Professor Trelease or any of the gentlemen interested in this Garden have had entomological instruction in mind to-night, though they all see the necessity for it. Professor Trelease tells you he feels the necessity for the services of an entomologist from time to time to protect the plants and flowers which are growing in the Garden, and I would say that in time there will be connected, no doubt, an entomologist with the horticultural or floricultural enterprise.

Hon. Charles E. Hay, of Springfield, Ill., was then called upon, and made the following remarks upon orchid growing by amateurs, a matter in which he has had much experience and flattering success:—

Mr. Chairman and Gentlemen: As Mr. Trelease was making his introductory remarks, the thought came up to me of a time when I went to hear a temperance lecture. A gentleman who was an advocate of total abstinence was traveling with the finest specimen of a drunken tramp that was ever seen. Some one asked him why he carried that man around with him, and he said, "To show every one the awful results of drunkenness." In my case, I presume I am the awful example of a man who might be called an amateur florist,— that is, one who has not been taught by others, but has simply taught himself. A number of years ago, I thought I would cultivate a few flowers, and I went to a practical business friend who had succeeded even better than I have since, and he told me that I might meet with many disappointments: that I would find no fish on the geraniums, although there are plenty of fish geraniums; that I would not find on the hubbard squashes any Mother Hubbard dresses, nor would I find any New York counts or blue points on the salsify. And

numerous other disappointments of that sort he said I would find, but, suffice it to say that, being eager, having all the eagerness of a young convert, I went to work to collect a few plants, and, later on, I collected a few orchids. And let me say that the first orchid I ever saw was a very solitary plant in a neighboring greenhouse. I did not know what it was. I simply saw on the label the name, and it was even wrongly named, as I learned afterwards. I thought I would buy a few orchids, and wrote to a friend of mine, who was a dealer, to order a dozen plants; but on the way to the post-office it occurred to me that a dozen might bankrupt me entirely. I did not know what they would cost, and I changed the letter before it went into the mail and asked the price first. I bought the dozen, however, and with that beginning I began the cultivation of orchids. To show that one as inexperienced as myself can succeed in keeping alive orchids, I will say that I think the majority of that dozen are to-day alive in my greenhouse. I had no greenhouse, strictly speaking, then,— nothing in the world but a little conservatory. But from the reading I did I concluded that I must have the requisite temperature for the hot-house orchids, and those that I had were ones adapted to medium temperature, and for the cooler temperature I subdivided that portion again. Later on, of course, I became a little more pretentious; and where then I had a dozen, I perhaps have now two hundred dozen.

Enthusiasts have said that there is a degree of intelligence in an orchid kindred to the intelligence that is in man. That as man is the noblest of the animal creation, endowed with the faculty of looking his Creator in the face and having an intellect to express his thoughts, the orchid, being the last created specimen of the floral kingdom, has some of those attributes. I do not say so myself, I am not so much of a crank as that, but there is something in the modern orchid corresponding to man. There are no traces of orchids found in the clay formations. No geologists

claim that they have found anywhere traces of them. They have found flowers, but no orchids. But I am not going to detain you in talking about the formation and origin of the orchid, or about its construction or reproduction, or anything technical. To my notion, having succeeded comparatively well myself, it is a very strange thing that instead of there being one thousand orchid growers in the United States there are not ten thousand. Because, after one has once acquired a knowledge of the conditions surrounding them in their native habitat, the rest is the simplest thing in the world. It is nothing in the world but common sense. To illustrate what I mean, in St. Louis, the rainfall is, perhaps, 50 inches; you must multiply that twelve times to get the necessary amount of moisture for an orchid. In its native habitat, in Burmah, the rainfall, I understand, is about 600 inches a year. The plants simply anchor themselves to something and live upon the atmosphere and the moisture. It is absolutely necessary to their health and well being that it must be clean moisture. They are very fastidious, and not only must they have air, but it must be pure air, and therefore a hot house would have to be so constructed as to afford the requisite degree of moisture and the proper atmosphere or ventilation. For example, an ordinary green house is better adapted in my judgment to the cultivation of the orchid than these large frame hot houses with curvilinear roofs. A house 16 feet wide, with a low roof, not over 12 feet high, the floors of earth, with walks cemented, and, if possible, an open tank in the center, with the shelving covered with either shingles or coarse gravel or broken cinders with the ashes all sifted out of them, is the best for the purpose. The ventilation should be well taken care of, because, as I have said, they are particular about the air they breathe.

There are over six thousand varieties known to collectors, and a third of that number, I believe, could be grown by an ordinary person who loves the plants and is willing

to devote a little attention to them. There is no potting to be done. Any lady can take care of them, and I know of no flower in bloom that, to use the English expression of a French friend, is so thoroughly fetching as the well grown orchid. So far as I am concerned, I do not know of any flower that I would rather devote myself entirely to than the orchid, and, for the reason, as Mr. Trelease has so well said, that I am absolutely fond of them. It does seem to me that when I am in the presence of an orchid I am in the presence of a plant that, as the old Irishman said, "has sense!"

In response to a call from the Chair, Mr. Edgar Sanders, of Chicago, then spoke of the value of horticultural libraries, presenting statistics of the principal collections of the kind existing in this country, and commending the effort of the Garden to gradually bring together as full a reference library in horticulture as possible. On the conclusion of his remarks, Mr. James Gurney, for many years Head Gardener at the Botanical Garden, was called upon, and spoke briefly of the aims and plans of Mr. Shaw as he knew them. Mr. W. A. Manda, of Short Hills, New Jersey, an accomplished gardener, and one through whom many plants have been introduced into the country during the past few years, then spoke as follows:—

Mr. Chairman and Gentlemen:— I feel greatly honored to be called upon for a few remarks, although I must say that I feel rather bashful, after hearing such eloquent speeches; but I respond knowing that every person interested in horticulture is willing at all times to overlook a diffident manner in one who follows that pursuit. In the few short years I have lived in this country I have seen the most remarkable progress in horticulture that it is possible to imagine. Only nineteen years ago there were very few private gardens, and there were hardly any exhibitions outside of Boston or Philadelphia, and those would not now be ranked as third class exhibitions. Now what?

In the past and present weeks there are being held and have been held throughout the country nearly fifty Chrysanthemum shows, some of which are of an extent calculated to make the exhibitions of the old country seem small and insignificant. In fact, there are Chrysanthemums grown in this country that have never been seen in Europe, and the same may be said of roses, or almost any other flower. The hard working and intelligent American, either native or adopted, has given his whole heart to his work. Horticulture is advancing, and enterprise is everywhere. There are to be sure establishments where plants are simply manufactured, so to speak, instead of grown: — just so many hundred thousand sent out annually. But we must look for this progress chiefly to those others who raise new varieties, either from the seed or by means of better methods, or to those who introduce new and unknown plants from the tropics, rather than to those who are merely in the profession for the money there may be in it. I think there is more credit in either raising a new and superior variety of an already existing kind, or introducing a new and desirable plant from the tropics — there is more credit to a man from that one plant than there is in growing a million plants annually of an established variety.

I think, gentlemen, that this kind of horticulture should be more encouraged; and I am pleased to see that amongst the premiums offered at your coming St. Louis exhibition, is one given by the Trustees of the Garden founded by Mr. Shaw, for encouraging such work. It is only by being wholly interested in plants, and not in the dollars and cents that may be in them, that we can interest others. I do not see why every florist should not have a few choice plants that he prizes so much that money could not buy them from him. Such plants he could improve and raise new varieties of, and thereby interest amateurs far more than by only saying of his plants, "Well, so much a thousand, or so much a hundred!" — a few plants such as old Mr. Menand had, when he said to Mr. Smith, the Curator of the Botanical

Gardens at Washington, "The United States has not money enough to buy that plant." How many men will you find of that kind? I only know two. Mr. Hovey, who is resting peacefully now, and this Mr. Menand. Between those gentlemen, I believe, is to be divided the credit of starting nearly all the collections we know at present. I hope, gentlemen, that by doing this kind of work, we will be able to interest outsiders in our work, and if we do not get them quite as thoroughly interested as the late Mr. Shaw, that at any rate they will do in a smaller way what that noble gentleman did so well and so completely for horticulture and for the benefit and betterment of mankind. What he has provided in his will is that the good he was doing while he was living shall last and be a lasting good as well as an enduring monument to himself.

Mr. Manda was followed by Mr. W. S. Chaplin, Chancellor of Washington University, who spoke as follows:—

A few minutes ago I asked the Chairman of the evening how long I could speak, or, rather, how long I should speak, and he gave me to understand that as I was the last speaker I could speak till daylight. I do not intend, however, to inflict on you more than a few minutes' talk. I wish to say to you that, when considering whether I should come to Washington University or not I, of course, made many investigations, and in these investigations I was sorry to find that St. Louis was almost an unknown city in the part of the country that I come from. I wish to suggest right here that whether it is on account of the innate modesty of the people of this city, or whether it is because this city has not borrowed a great deal of money from the East, or whatever the reason may be, St. Louis is less known, say in New England, than any other great city of the west. That I drop just as I am passing. One of the things that I noticed in this investigation which I spoke of was, of course, the Shaw bequests, and among them I noticed a peculiar provision, one which I believe has not

been established in any other place in this country, — namely, that a dinner should be given to gentlemen interested in horticulture. Of course, being a yankee — at that time — being a yankee at that time, I began to ask why this was so. Why did Mr. Shaw make any such provision? The first reason, of course, was that Mr. Shaw wished to get together a number of gentlemen who would enjoy a good dinner. Certainly, so far, the enjoyment has been complete. I might have stopped there, and said that out of his kind heart he had made this provision for your pleasure. But, looking it over, I saw that Mr. Shaw was a very far-sighted man and that he had really a deep strong reason for founding — for establishing this feast. Mr. Shaw must have seen what every scientific man sees, — that for the advancement of knowledge there is necessary a strong, active co-operation between the man who is investigating and the man who is applying. I know that practical men have something this idea of an investigator, — that he is rather a dried up specimen of humanity, much given to books, living on very little food, dying late in life because he forgets to die sooner. Scientific men have a somewhat similar idea of practical men — I mean to say, a similarly false idea. They have an idea that the practical man cares nothing for the truth. Now both of those ideas are radically wrong. After you work down into men's reason for laboring in any way you find that every honest man is not working for money, he is not working for knowledge, alone; but he is working, if he be an honest man, to serve his fellow men. The scientific man has as much a right to exist as the practical man; and the practical man must exist in order that anybody may exist. Mr. Shaw saw this fact, and I believe that he established this dinner that these two classes of men might be brought together. He wisely arranged that the Director of the Botanical Garden should preside at this feast. If he had done nothing more, gentlemen, than to bring you together so that you might meet with a gentleman of

Professor Trelease's eminence in botany, he would have had a worthy object.

Now this is what I wish to plead for: that you may give — that you all give — your assistance in keeping up the proper relation between the men who make the research and the men who apply the facts that are discovered. You know it has been said that no discovery is complete until it has been applied. The scientific men can assist you, you can assist the scientific men.

I wish before I close, — I know it is not morning yet, but morning will come by and bye, — I wish before I close to caution you in one respect. It is a tendency everywhere when some one man has stepped forward and done a great thing, made a great gift for any kind of a purpose, for all the rest of us to hang back and give him all the credit and do none of the work ourselves. I think there is a tendency here, since you are all human I think there may be a tendency here, for you to consider that Mr. Shaw has done all that botany needs. Let me say to you that if Mr. Shaw's benefaction were ten times as large as it is every dollar of it might be worthily expended in the study of botany, in the collection of herbariums, in the establishment of means of widening human knowledge. It is, then, a worthy thing that Mr. Shaw has done. It will be a worthy thing in you if you support his ideas and help to broaden them and extend them to other men. I feel that it was a wise thing in him also to establish this garden right here in St. Louis. You have here everything favorable for the extension of botanical knowledge. You are centrally placed in the United States, you have a climate almost unequalled, you have a soil which seems to be inexhaustible to a man who has just come from that stony gift of God called New England. You have markets. Why, a year or two ago, when I was in Mexico, the one thing I found that looked like home was apples from St. Louis. The man who had those apples made a very bad speculation. The fact was, the people down in Mexico were not educated up to eating apples; but

I see there is a commission down there now from this city, and if you wished to exemplify the practical operation of eating apples I should be very glad to present myself as a terrible example of the effect of eating them. You have, then, a bountiful soil; you have all ranges of climate (I have noticed that within the last few days), in fact, you have everything that can assist you, and it seems to me that you may well expect the Henry Shaw Gardens to become what they fairly promise to become, that is, the greatest botanical gardens in the United States.

In conclusion, the Chairman said: We have with us this evening gentlemen who know how to grow apples and who know how to market apples; who know how to grow seeds and who know how to market seeds; who know how to grow roses, and how to market them; and so of the various other floral and agricultural products. But the hour is growing late, and I do not feel that it would be a pleasure to those gentlemen, and possibly not to all of you, since some of you have to go a considerable distance before reaching home, if I were to call on other speakers this evening. I have received in connection with the invitations for this dinner numerous appreciative letters, responses from prominent men all over the country, a number of whom had expected to be with us and have wired me even to-day that at the last moment they found they could not come:—the chief of the Forestry Bureau of the Department of Agriculture, the Horticultural Chief of the World's Fair in Chicago, the Secretary of our State Horticultural Society, the Secretary of the Massachusetts Horticultural Society, who has been so highly spoken of this evening, and other gentlemen equally distinguished, whom we all wished to meet here and whom we hope to meet some time. These letters would interest you, if there were time to present them properly; but I feel that we have detained you longer than we should this evening, and so I thank you for coming and once more bid you welcome to the Missouri Botanical Garden and to these banquets which Mr. Shaw has provided.

SCIENTIFIC PAPERS.

A REVISION OF THE AMERICAN SPECIES OF RUMEX OCCURRING NORTH OF MEXICO.

BY WILLIAM TRELEASE.

The following revision is based on a study of the material contained in the Engelmann, Bernhardi, and general herbaria of the Botanical Garden, and in the herbaria of Harvard University, the United States Department of Agriculture, Columbia College (including the Meisner herbarium), and the California Academy of Sciences, and the private collections of Capt. J. Donnell Smith, Dr. Chas. Mohr, Mr. W. M. Canby, Mr. I. C. Martindale, Prof. Jos. F. James, Mr. A. S. Hitchcock and Mr. H. J. Webber. Critical species, and material for the Garden herbarium, have also been contributed by many correspondents. My cordial thanks are hereby tendered all who have thus aided me; and I have particularly to thank Professor Areschoug of the Lund University, for the donation of a critical set of Scandinavian docks, especially rich in hybrids.

Rumex is a genus which has been held to include from 100 to about 130 species, the greater part of which belong to the north temperate region of both continents, though a considerable number occur south of the equator, and a few reach up into the Arctic regions. The principal monographs of the genus are by Campdera,* and Meisner.† For the general synonymy of our species, I have contented myself with references to the latter. Of the twenty-one

* Monographie des Rumex, Paris, 1819,— a paper which I have not seen.

† In De Candolle's Prodromus, xiv., Paris, 1856, 41. For other references see Bentham and Hooker, Gen. Plant. iii. 100.

species recognized by me as occurring within our flora, eleven were characterized and named by Linnæus in the first edition of the Species Plantarum, and only five have been named by American botanists. As a rule, though puzzling to the novice, they are well marked, and I have been able to complete my revision of the principal American material without seeing the necessity of designating any forms as new, though it may be that those mentioned under *salicifolius* and *crispus* will ultimately demand recognition as separate species. As illustrating the degree to which one so disposed may multiply species, it may be stated that in a very limited local flora (that of Lyon, France), Gandoger in 1875 (*fide* Just, iii, 685,) described sixteen new species, which other botanists are disposed to consider only forms or hybrids of familiar species. The practice of applying new specific names to known hybrids is also calculated to increase unwarrantably the enumerated species of a given region, since some of the docks and sorrels are known to hybridize quite freely.

One of our twenty-one species is merely a ballast introduction; seven others are Old World weeds; two (*Acetosa* and *salicifolius*) are apparently arctic-alpines of wide distribution, while the other eleven belong essentially to the North American flora.

Among the more important references to the specific delimitation of docks, aside from the monographs already referred to, should be noted: — Trimen, various papers in Journal of Botany, about 1873; Haussknecht, Oesterr. Bot. Zeitschrift, 1876, xxvi. (Just, 1876, part 2, 963 and 988), and Mittheil. Geogr. Ges. f. Thüringen, Jena, 1884, iii. 56–79 (Just, xii. part 2, 592), — where many hybrids are named; Murbeck, Beitr. z. Kenntn. der Flora von Südbosnien u. d. Hercegovina, in Lunds Universitets Aarsskrift, 1891, xxvii.; and Rechinger, Oesterr. Bot. Zeitschr., 1891, 400.

The chief biological interest in the genus comes from the protective acidity of the sorrels and some docks and the

occurrence of tannin and a bitter principle in others; their protandry and exclusive adaptation to wind pollination (*cf.* Müller's writings, and notes by Thomson in Trans. Bot. Soc. Edinburgh, xiv. 105, and Tulberg in Bot. Notiser, 1868, 12); and the adaptation of the greater number of species to wind dissemination, by the enlargement of the inner segments of the perianth during ripening, although some of those with fimbriate valves may profit by attachment to animals, while *R. Lappula* and *R. hamatus* form veritable burs, as Huth has shown in Bibl. Bot. 1887, No. 9, p. 13 (Just, xv. part 1,433). Causation of sex in the dioecious *R. Acetosella* is discussed by Hoffmann in Bot. Zeitung, xliii. Chatin describes the organogeny of the andrœcium in Comptes Rend. vol. 78, 254 (Just, 1874, 479). Herail considers the anatomy of the stem, in Ann. des Sci. Nat. 7 ser. ii. 283 and 286; and Hanstein describes the mucilage glands of the buds in some cases in Bot. Zeit. 1868, 699 and 799. The occurrence of tannin in considerable quantities is considered by Bandelier in Verhandl. Gesellsch. f. Erdkunde zu Berlin, 1885, xii (Just, xiii. part 2, 234); and Borscow notes the presence of chrysophanic acid in the roots, in Bot. Zeit. 1874 (Just, ii, 126, 834). Other references concerning economic products and properties in the genus, — few species of which are of any considerable economic importance, — are given under the several species, particularly *R. hymenosepalus*, and the copious indexes of such pharmaceutical periodicals as the American Journal of Pharmacy.

SYNOPSIS OF NORTH AMERICAN SPECIES.

§ *Acetosella.* — Dioecious: inner segments of perianth without dorsal callosity, not reticulated, not larger than the achene: foliage acid.— Perennial.

1. R. Acetosella, L. — A span to exceptionally a foot or two high, tufted, propagating by creeping roots; leaves rarely 5 cm. long, oblanceolate, acute, the lower mostly

hastate with a large decurrent rarely 1-toothed auricle on each side, the upper gradually reduced and entire; panicle more or less compound, usually reddish, the filiform ascending branches leafless; pedicels capillary, once or twice as long as the flower, articulated at summit; flowers about 1.5 mm. the outer sepals granular; achene four-fifths as broad as long. Sp. i. (1753), 338; Meisner, DC. Prod. xiv. 63.— Introduced from the Old World, a weed everywhere especially in dry poor soil. — Specimens examined from British America from Prince Edward's Island and Nova Scotia to Vancouver Island; and from Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, West Virginia, North Carolina, South Carolina, Florida, Mississippi, Louisiana, Ohio, Minnesota, Michigan, Wisconsin, Illinois, Missouri, Iowa, Kansas, Colorado, Texas, and California. — Plate 13.

§§ *Acetosa*.— Dioecious: inner segments of perianth (valves) rather finely reticulated, becoming round-cordate and much larger than the achene: foliage acid: inflorescence with slender leafless branches.— Perennial.

2. R. HASTATULUS, Baldw. — Tufted, mostly a foot or two high, leaves exceptionally 2.5x10 cm., oblong or oblanceolate, obtuse to subacute, some of them, especially on pistillate plants, hastate with a short and often broad spreading auricle on each side; panicle mostly ample and rather open; pedicels capillary, once or twice as long as the fruit, obscurely articulated below the middle; valves about 4 mm. in diameter, short clawed, sometimes slightly pointed, without callosities, the middle sometimes papillate; achene 1x1.5 mm.— Muhl. Cat. 2 ed. (1818), 37; Elliott, Sk. Bot. S. C. and Ga. i. (1821), 416; Watson, Bot. King. 314. — *R. Engelmanni*, Meisner, DC. Prod. xiv. 64. — Sandy bluffs and fields, Long Island to Florida, in the lower Mississippi Valley, and in Texas.— Specimens examined from Aquebogue, (*Young*, 1873), and Wading River, Long Island, (*Miller*, 1873, 1878), New Jersey, (*Smith*,

1890), North Carolina, South Carolina, Georgia, Florida, Alabama, Louisiana, Mississippi, Illinois, Missouri, Indian Territory, and Texas, one collection (*Hall*, 1872, 540 in various herbaria) with sublinear very hastate leaves.—Plate 14.

3. R. Geyeri, (Meisner). — Somewhat tufted, about a foot high; leaves exceptionally 3x9 cm., spatulate to lanceolate or the shortest somewhat elliptical-ovate, obtuse or acute, very gradually narrowed at base, neither auricled nor hastate; inflorescence rather simple, with suberect branches; pedicels about as long as the fruit, jointed toward the base; valves about 4 mm. in diameter, clawless, sometimes with a very minute rounded basal callosity; achene 1x2 mm.— *R. Engelmanni*, *β Geyeri*, Meisn. in DC. Prod. xiv. (1856) 64.—*R. paucifolius*, Nutt. Mss., Watson, Bot. King. (1871), 314.— Parks etc., in the mountains, from Wyoming and British America to Colorado, Utah, and California. — Specimens examined from N. Kootanie Pass, Brit. Amer. (*Dawson*, 1883), Montana (Flathead River, *Nuttall*), Wyoming (*Hayden*, 1860; *Parry*, 1873, 249; *Forwood*, 1881, 66), Yellowstone Park (*Letterman*, 1885; *Knowlton*, 1888), Colorado (North Park, *Sheldon*, 1884, 135), Utah (*Watson*, 1869, 1054; *Porter*, 1873), Idaho (*Hayden*, 1871), Washington (*Suksdorf*, 1883; *Brandegee*, 1883, 1068), Oregon (*Geyer*, 488; *Lyall*, 1860; *Cronkhite*, 1864; *Cusick*, 1881, 984), and California (*Brewer*, 1863, 1696; *Lemmon*, 1874, 711; *Shockley*, 1886, 495). — Plate 15.

4. R. Acetosa, L.— Simple, a foot or two high, frequently papillate about the nodes and on the midrib of leaves; leaves occasionally 4x10 cm., ovate or oblong-ovate, mostly obtuse, deeply cordate with commonly acute auricles, or subsagittate, a small tooth sometimes present on each auricle; inflorescence rather simple and compact; pedicels about as long as the fruit, conspicuously jointed in the middle; outer sepals of pistillate flowers relatively large,

reflexed even in flowering; valves orbicular, 5 mm. in diameter, clawless, usually with a delicate callosity at base; achene 1.2x2.5 mm. — Sp. i. (1753), 337; Meisner, DC. Prod. xiv, 64.— Apparently indigenous from Labrador to Lake Superior, Alaska, and Oregon; and introduced from the Old World at a few points in the Northern States probably as a waif from gardens, in which it is sometimes cultivated for its acid foliage. — Specimens examined from Labrador (*Bryant*, 1860), Toronto (*Macoun*, 1878) and Point aux Pins, Canada (*Macoun*, 1869, 84), N. Shore L. Superior (*Pitcher*), Quatcho Lake (*Dawson*, 1876), Morley (*Macoun*, 1885), and Arctic N. A. (*Richardson* on Franklin Exp.), Alaska (hb. Dep. Agr.), Vancouver Isl. (*Macoun*, 1887), Oregon (*Hall*, 1871, 442; *Howell*, 1882), Charlotte, Vt. (*Pringle*, 1877, 1879), Penn Yan, N. Y. (*Wright*), and Brookfield, Pa. (*Canby*, 1862).—Plate 16.

§§§ *Lapathum.*— Hermaphrodite or andro-monoecious: inner segments of perianth (valves) commonly reticulated, becoming round or elongated and much larger than the achene: leaves only exceptionally acid, never hastate: inflorescence with stouter sometimes leafy branches.— Perennial except *R. persicarioides* and *R. bucephalophorus*.

* Valves at most very minutely erose or low-denticulate.

+– Valves very large (15 to 50 mm. long), mostly rosy, round or broadly ovate, deeply cordate, without callosities: whorls rather remote but overlapping in fruit: outer sepals at length reflexed: stipular sheaths very large and loose.

5. R. VENOSUS, Pursh.— A span to mostly about a foot high (from deep-seated thin roots?), branching from most of the axils and spreading, glabrous; leaves firm, not wavy, at most 5x10 cm. elliptical or elliptical-ovate, abruptly acute at both ends; inflorescence nearly simple, leafless, the short zigzag branches divergent; pedicels rather stout, about as long as the fruit, tumidly jointed below the middle; valves rather firm, orbicular or broader than long, 20 to 50 mm. in diameter, the sinus often closed, emarginate to shortly blunt acuminate; achene 4x7 mm.— Fl. ii. (1814), 733; Meisner, DC. Prod. xiv.— Dry sandy soil in the plains

and foot hills, British Columbia to Oregon, Nevada, Dakota and Kansas. — Specimens examined from Qu'Appelle (*Macoun*, 1879, 192 and 1534) and Swift Current, in British America (*Macoun*, 1884); and from Washington (*Brandegee*, 1883, 1067; *Suksdorf*, 1886, 896), Oregon (*Spalding; Suckley*, 1855; *Lyall*, 1860; *Howell*, 1880 and 1881; *Cusick*, 1881, 983; *Henderson*, 1886, 103), Montana (*Hayden*, 1860; *Scribner*, 1883, 247; *Tweedy*, 1888, 104), Wyoming (*Hayden*, 1853–4), Dakota (*Hayden*, 1853; *Glatfelter*, 1865, 376; *Vasey*, 1868, 499; *Canby*, 1883, 278; *Manning*, 1884), Nevada, (*Anderson*, 1865, 243; *Watson*, 1868, 1048), Utah (*Hayden*, 1859; *Jones*, 1880, 1729), Colorado (*Hall and Harbour*, 1862, 495; *Parry*, 1867, 186; *Brandegee*, 1874; *Farwell*, 1890), and Kansas (*Damon*, 1888; *Kellerman*, 1889).— Plate 17. Young plants distributed from Oregon by Howell in 1885 may possibly belong here, possibly to *salicifolius*.

6. R. HYMENOSEPALUS, Torr. — One to three feet high, from a cluster of deep-seated Dahlia-like tuberous roots, subsimple, papillate to glabrous, often red; leaves rather succulent, more or less wavy margined, often 5x20 cm. or larger, elliptical to oblanceolate, obtuse to very sharply acuminate, the acute base decurrent on the short thick petioles; inflorescence ample, compound, with elongated suberect branches; pedicels slender, about as long as the fruit, less tumidly jointed below the middle; valves flexible, ovate, about 10x15 mm., obtuse to subacute, with an open sinus; achene 3x5.3 mm. — Bot. Mex. Bound. Surv. (1858), 177; Watson, Bot. Calif. ii. 8, 479; Parry, Amer. Nat. ix. 350; Greene, Am. Nat. xii. 175; Havard, Proc. Nat. Mus. 1885, 525; Vasey & Rose, Contr. Nat. Herb. i. 11; Brandegee, Pl. from Baja, 204; Rusby, Drug. Bull. Nov. 1890.—*R. Saxei*, Kell. Pac. Rur. Press, 1879; *R. Arizonicus*, Britt., Trans. N. Y. Acad. viii. (1888), 73. — Dry soil in the plains and lower mountains, California and Lower California to Utah, the Indian Territory, and Texas. — Specimens

examined from California (*Bigelow*, 1854; *Egloffstein*, 1854; *Brewer*, 1863, 405; *Bolander & Kellogg*, 1866; *Vasey*, 1880, 547, and 1881; *Mrs. Bush*, 1880; *Pringle*, 1882; *Parish*, 1882 & 1884, 678, 1888; *Brandegee*, 1886; *Hasse*, 1888), Lower California (*Palmer*, 1889, 689, 829), Arizona (*Palmer*, 1867, 224; *Lemmon*, 1881, 281), Utah (*Mrs. Thompson*, 1872; *Parry*, 1874, 246; *Palmer*, 1877, 422; *Jones*, 1880, 1643), New Mexico (*Fendler*, 1847, 758; *Wright*, 1852, 1782; *Bandelier*, 1882; *Matthews*, 1883), Indian Territory (*Palmer*, 1868, 291), and Texas (*Thurber*, 1855, 140; *Reverchon*, 1882, 129). — Plate 18.

+– +– Valves small or medium sized (not over 10 mm.long), only moderately if at all cordate.

++ Valves round or very broadly ovate, flexible, low-reticulate: pedicels slender or capillary: stems glabrous except in *R. crispus*.

7. R. OCCIDENTALIS, S. Wats.— Mostly two or three feet high, erect or abruptly ascending, rather stout, subsimple; leaves somewhat fleshy, glabrous, glossy, bluish green, wavy margined, the lower ample or very large, ovate or mostly oblong-ovate, truncately cordate, the apex rounded to subacute; panicle strict, dense and rosy in fruit, naked or with few small leaves below; whorls somewhat remote but overlapping; pedicels 2 to 3 times as long as the fruit, very obscurely and not tumidly jointed below the middle; valves sometimes rosy, 5 to 6 mm. long (exceptionally 7x9 mm.) deltoid-ovate, often only slightly cordate, remotely erose or denticulate, rounded or obtuse at apex, without callosities (but one midrib occasionally somewhat thickened); achene 2 to 2.5x4 mm.—Proc. Amer. Acad. xii. (1876), 253.—*R. longifolius*, Meisner, DC. Prod. xiv. 44, as to the American plant and its synonyms.— Damp or rich soil, Labrador to Alaska, south to Canada, California, and in the mountains to Texas. —Specimens examined from Labrador (*Storer; Allen*, 1882, 64), Hudson's Bay (*Bell*, 1884), Arctic America (*Richardson* on Franklin Exp.), Canada (*Allen*, 1881; *Macoun*, 1883), Saskatchewan (*Bourgeau*, 1858) and

various points in British Columbia; and from Alaska (*Tiling*, 1867, 159; *Dall & Harrington*, 1872; *Nelson*, 1877; *The Albatross*, 1888, 2), Washington (*Suksdorf*, 1885, 604), Oregon (*Lyall*, 1858; *Howell*, 1877, 355, and 1880), California (*Blankinship*, 1891, *Mrs. Austin*, 1880), Idaho, (*Sandberg*, 1887), Montana (*Canby*, 1882), Nevada (*Watson*, 1868, 1049), Utah (*Ward*, 1875, 411), Colorado (*Hall & Harbour*, 1862, 158, 499; *Vasey*, 1868, 498; *Greene*, 1870, 352, and 1871, 548; *Engelmann*, 1874 and 1881; *Brandegee*, 1877; *Trelease*, 1891), Arizona (*Lemmon*, 1882, 2879), New Mexico (*Fendler*, 1847, 759), and Texas (*Ravenel*, 1869, in hb. Dep. Agr.)—Related to *R. aquaticus*, L. (which was collected on ballast at Camden, N. J., in 1879 by Mr. Martindale). — Plate 19.

Var. NANUS (Hook.), *R. domesticus*, *β. nanus*, Hook., Bot. Bor. Amer. ii. (1840), 129, probably comprises the simpler and more dwarf purple-stemmed plants of northwest Arctic America and the adjacent islands, which have been variously referred to *domesticus*, *longifolius*, and *arcticus*. They have commonly rather thick and succulent stems and subelliptical leaves, but all that I have seen are too immature for satisfactory determination with my present knowledge of the genus. — Specimens referred here doubtfully: — *Wright*, on Ringgold and Rodgers Exped.; *Stejneger*, 1882, 12, and 1883, 50; *Dall*, 1872; *Muir*, 1881, 125 and 217 (the last from Siberia); *Murdoch*, 1883; and *Str. Corwin*, 1884. — A very similar plant in hb. California Academy from Golovnin Bay (*Yemans*, 1884).

8. R. PATIENTIA, L. — Usually about three feet high, erect, stout, subsimple; leaves acid, usually quite wavy, ample or the lowest very large, ovate-lanceolate and elliptical, acute, the base rounded or decurrently acute, the principal veins often slightly papillate below; panicle strict, very dense in fruit, with few small leaves; whorls compact and approximate; pedicels nearly twice as long as the fruit, tumidly jointed near the base or below the

middle; valves 5 to 8 mm. in diameter, orbicular or broader than long, conspicuously cordate, erose or obtusely low dentate below, round or bluntly short acuminate at apex; callosities solitary (exceptionally wanting or a second or third developed), globose, smooth, rarely 1 mm. long; achene 2x3.5 mm. — Sp. i. (1753), 333; Meisner, DC. Prod. xiv. 51. — Introduced along roadsides and in fields at various points in the Atlantic States, from Europe, where it is cultivated for its acid foliage; possibly escaped from German kitchen gardens in its American stations. — Specimens examined from Saskatchewan (*Macoun*, 1872, 1030), Ontario (*Macoun*, 1874), Vermont (*Jesup*, 1873), Massachusetts (*Hitchcock*, 1829; *Tuckerman; Jesup*), New York (*Howe; Brown*, 1879, on ballast), New Jersey (*Schrenk*, 1879, and *Martindale*, 1880, on ballast), Pennsylvania (*Martindale*, 1882), Wisconsin (*Trelease*, 1887), Iowa (*Hitchcock*), Kansas (*Kellerman*), and Utah (Jordan Valley, *Watson*, 1869, 1050), — the last named locality quite out of the usual range, but the plants scarcely anything else. — Plate 20.

9. R. Britannica, L. — Three or four feet high, erect, stout, at length considerably branched; leaves glabrous, little undulate, ample or the lowest very large, elliptical to ovate lanceolate, decurrently rounded or commonly acute at base, the apex very gradually pointed; panicle few leaved, ample, rather dense in fruit; whorls rather dense, remote but at length overlapping; pedicels about twice as long as the fruit, very obscurely and not tumidly jointed toward the base; valves 4x4.5 to 5x6 mm., round ovate, scarcely cordate, remotely erose or low-denticulate, obtuse, their lower veins sometimes much thickened at base; callosities 3, subequal, broad and low, sometimes wrinkled on the sides, more than half as long; achene 1.7x3.5mm.— Sp. i. (1753), 334; Gray. Proc. Amer. Acad. viii. 399.— *R. orbiculatus*, Gray, various editions of the Manual.—Swamps, New Brunswick to the Lakes, south to New Jersey, Illinois,

and Iowa.— Specimens examined from New Brunswick (*Chalmers*, 1876; *Fowler*, 1870, 1871, with valves evidently toothed and very unequal in the same panicle, some of them 8 mm. long), Prince Edward's Island (*Macoun*, 1888) and other points in Canada (*Macoun*, 1865, 1882, 1888), Maine (*Redfield*, 1889), New Hampshire (*Blake*, 1861), Massachusetts (*Boott*, 1864, 1866; *Robbins; Jesup*, 1872, 1876; Rhode Island (*Congdon*, 1873, 1878), Connecticut (*Eaton; Potter*), New York (*Torrey; Vasey*, 1882), New Jersey (*Austin*, 1861; *Britton*, 1887), Pennsylvania (*Wolle*, 1841, 47; *Garber*), Ohio (*Lea*, no. 10), Illinois (*Vasey*), Michigan (*Wright*, 1838; *Robbins*, 1863, 52), Minnesota (*Douglass*, 1891), Wisconsin (*Lapham*, 1843; *Pammel*, 1887), and Iowa (*Arthur*, 100; *Hitchcock*). — Plate 21.

10. R. CRISPUS, L.— A couple of feet high, erect, rather stout, simple, glabrous to slightly papillate, leaves bluish green, the petiole and principal veins papillate, very wavy margined, the lowest ample, elliptical to mostly oblong-lanceolate, rather obtuse, rounded or decurrently acutish at base; flowering branches rather strict, somewhat leafy; whorls dense and approximated; pedicels about one-half longer than the fruit, tumidly jointed near the base; valves 3 to 5 mm. long, round-ovate, barely cordate, rounded or with a broad blunt acumination, minutely erose or exceptionally broadly dentate below; callosities 3, subequal, or two smaller, often rosy, smooth, ovoid, reaching to the middle of the valve; achene 1.5x2.5 mm.—Sp. i. (1753), 335; Meisner, DC. Prod. xiv. 44.—Roadsides, pastures, etc., everywhere; introduced from Europe.— Specimens examined from various points in Canada, Maine, Massachusetts, New York, Delaware, Maryland, District of Columbia, Virginia, South Carolina, Alabama, Florida (*Chapman*), Mississippi, Louisiana, Indian Territory, Ohio, Illinois, Missouri, Michigan, Minnesota, Wisconsin, Iowa, Nebraska, Colorado, Utah (*Jones*, 1879, 1183), Wyoming?

(*Jones Exped.* 273), Idaho (*Sandberg*, 1887, 75), Vancouver Island (*Macoun*, 1887), and California.—Plate 22.

Slender Californian plants with crisp sub-papillate leaves, simple elongated panicles, and rather large valves, one of them with a callosity, referred here with some doubt, occur as follows in the Gray herbarium.—Monterey (*Brewer*, 1863, 694); Oakland? (*Brewer*, 1863, 2597); Cambria (*Palmer*, 1876, 460 in part, some of the specimens being *R. pulcher* in hb. Dept. Ag.), and San Bernardino (*Vasey*, 1880).

↔ ↔ Valves triangular-ovate to oblong, sometimes with a contracted apex.

= Pedicels long and slender but rigid, abruptly reflexed near the base then straight; valves rigid, with heavy veins, all of them with elongated wrinkled callosities: glabrous throughout.

11. R. VERTICILLATUS, L.—A couple of feet high from a cluster of short conical roots, erect or quickly ascending, or occasionally decumbent and rooting at the nodes; rather slender, subsimple; leaves not wavy, the lower sometimes 5x40 cm., lanceolate or mostly oblong lanceolate, gradually acute at each end; petioles spongy; inflorescence nearly leafless, with few ascending branches; whorls dense, very remote below; pedicels thrice as long as the fruit, tumidly jointed close to the base, gradually thickened toward the flower; valves 4x4 to 5 mm., deltoid to subhastately 3 lobed, more or less cuneate at base; callosities 1 mm. broad and as long as the valve exclusive of its apical lobe; achene 2x3.5 mm.—Sp. i. (1753), 334; Meisner, DC. Prod. xiv. 47.—Swamps, commonly close to the water, Canada to Florida, Texas and Iowa.—Specimens examined from Ontario (*Macoun*, 1877, 1540), Vermont (*Jesup*, 1873), Massachusetts (*Jesup*, 1875), New York (*Carey*, 1834; *Gray; Boott*, 1855; *Beck; Sartwell*), Pennsylvania (*Hb. Bernhardi.*), Delaware (*Canby*, 1866), Maryland, (*Smith*, 1879), Florida (*Rugel*, 1843; *Chapman; Deane; Saurman*, 1868; *Palmer*, 1874; *Keeler; Canby*, 1889),

Alabama (*Mohr*), Louisiana (*Lindheimer*, 1859; *Hale*), Texas (*Wright; Lindheimer*, 1843, 93), Ohio (*Riddell*, 1838), Indiana (*Canby*, 1862), Illinois, Michigan, (*Wright*), Wisconsin (*Hale*, 1861; *Douglas*), and Iowa.—Plate 23.

= = Pedicels shorter, arcuately recurved: valves more flexible and with lighter veins except in *Floridanus*, one or more of them with elongated callosities, except in forms of *altissimus*.

a. Stem often glaucous, especially in the second: leaves pale green, lanceolate, minutely crenulate-crisped, not undulate nor cordate: inflorescence nearly leafless.—Glabrous throughout.

12. R. FLORIDANUS, Meisner.—A couple of feet high, slender, simple or with a few suberect branches; leaves scarcely over 1.5x8 cm. (the lowest dying early), strongly crenulate, lanceolate, subacute; panicle leafless, simple, the few branches nearly erect; whorls very dense, the lower remote, the upper closely approximated; pedicels rather stout, once or twice as long as the fruit, in the former case concealed, tumidly jointed about the middle, apophysate next the flower; valves 3.5 to 4 mm. long, deltoid, slightly blunt-pointed, with rather heavy veins; callosities 3, subequal, less than 1 mm. broad, two-thirds as long as the valves, finely warty and somewhat wrinkled; achene 1.8 x 2.7 mm.—DC. Prod. xiv. (1856), 46.—Known to me only through specimens from New Orleans (*Joor*, 1885) and Pointe a la Hache, La. (*Langlois*, 1880, no. 135, 1884, and 1885, no. 96), but presumably extending along the Gulf coast to Florida, where the type was collected by Rugel.—Plate 24.

The inflorescence is suggestive of simple forms of the next species, but the leaves are more crenulate, and the fruiting valves are as heavily veined as in *verticillatus*, to which most of the material referred here by collectors apparently belongs.

13. R. ALTISSIMUS, Wood.—Two or three feet high from one or several long conical roots, rather slender,

scarcely clustered, with ascending branches at or after flowering; leaves as much as 7x20 cm., little crenulate, broadly lanceolate to ovate lanceolate, acute, mostly rounded at base; inflorescence with several or in large plants numerous rather divergent branches, at length congested; whorls dense, approximate; pedicels rather slender, about as long as the fruit, tumidly jointed toward or near the base, more conically thickened; valves 4x5 mm., deltoid, sub-acute; callosities 3, subequal (or occasionally one or none), white, wrinkled and pitted, 1 mm. wide and two-thirds as long as the valve; achene 1.8x3 mm. — Class Book, (1847?), 477; Gray, Proc. Amer. Acad. viii. 399.— *R. Britannica*, Meisner, DC. Prod. xiv. 47; Gray, Manual, editions prior to the 6th, not. L. *fide* Gray. *l. c.* — Rich soil, especially near brooks, etc., Massachusetts and New York to Dakota, south to the District of Columbia, Nebraska, and Texas. — Specimens examined from Nahant, Mass. (*Oakes*, as *R. pallidus*, Bigelow), western New York (*Clinton*, 1864), Pennsylvania (*Porter*, 1857; *Garber*, 1868), Maryland (*Smith*, 1881), District of Columbia (*Ward*, 1876, 1879; *Mohr*, 1882), West Virginia (*Mertz*, 1877 and 1878), Ohio (*Frank*, 1835; *Lea; James*), Indiana (*ex hb. Wood.*), Illinois, Wisconsin, Dakota (*Geyer*, 1839, 143; *Hayden*, 1853; *Glatfelter*, 1865, 376 in part), Nebraska (*Webber*, 1886; *Holms*, 1889), Kentucky, Missouri, Iowa, Indian Territory, (*Butler*, 1877, 6), and Texas? (*Reverchon*, 1876; *Tweedy*, 1880; *Jermy*, 149). According to memoranda on a St. Louis specimen in the Meisner herbarium, Meisner regards this as the same as *R. Claytonii*, Campdera; but there is too much doubt concerning this point for me to displace the now established name given by Wood.— Plate 25.

14. R. SALICIFOLIUS, Weinm. — Habit and aspect of the preceding but more tufted and ascending; leaves rarely over 2.5 x 15 cm., lanceolate, often falcate, acute at both ends; pedicels scarcely equalling the fruit or a few in each

cluster longer, jointed near the base; valves 2 to 3 x 4 to 5 mm., triangular ovate, acute, more delicately veined; callosities variable in number, smooth or mostly pitted, often nearly as long as the valve, 1 mm. or more broad, leaving typically a very narrow margin on each side; achene 1.3 x 1.7 to 2.5 mm. — Flora, 1821, 28; Meisner, DC. Prod. xiv. 47.—Arctic America across to Alaska, south to New Hampshire, the Great Lakes, and in the mountains to Southern California and Mexico, where it closely approaches *R. Mexicanus*. — Specimens examined from various British American points between New Brunswick and Vancouver Island; Alaska (*Tiling*, 1867, 394); and Maine (*Boott*, 1861; *Rand*, 1888), New Hampshire (*Canby*, 1866), Ashland, Wisconsin (*Farwell*, 1887), Keweenaw Co., Mich. (*Farwell*, 1890), Western Missouri! (*Bush*, 1890), Washington, Oregon (*Hall*, 1871, 441; *Lyall*, 1858, 1860; *Howell*, 1882), California, Montana (*Scribner*, 1883, 246), Idaho, Wyoming (*Forwood*, 1882, 177), Colorado, Utah (*Ward*, 1875, 540; *Palmer*, 1877, 421), New Mexico (*Fendler*, 1847, 760 and 761; *Rusby*, 1880), Arizona (*Coues and Palmer*, 1865), Nevada (*Watson*, 1868, 1051), Texas (*Merrill*, 1886), and Lower California (*Orcutt*, 1884). — Plate 26.

As here accepted, this species comprises several forms so far as the fruiting valves and achenia are concerned. The Asiatic form is said to have only one or two of the valves with callosity. In this respect two principal American forms may be distinguished: — *a*, with valves deltoid or abruptly acuminate, often evidently denticulate below, the margin conspicuous on either side of the frequently solitary callosity; *b*, with valves more narrowly triangular, nearly or quite entire, nearly concealed by the mostly 3 large callosities. The first in its more toothed form is var. *denticulatus*, Torr. Bot. Mex. Bound. (1859), 178. The second in its most pronounced form is var. *angustifolius*, Ledebour, Fl. Ross. iii. (1849), 504. It may be that these forms will bear separation, even from the Old World type; but the (frequently young) specimens in herbaria

show so many intermediate forms and admit of so poor a geographical delimitation, that I cannot find good grounds for recognizing more than a single species.

A more zigzag plant with broad elliptical rather firm leaves (3 x 8 cm.) and one valve almost covered by the very large callosity (1.5 to 2 x 3 to 4 mm.), the other two naked, occurs from Sta. Cruz Mountains (*Kellogg & McLean*, 1876, 597), Sta. Lucia Mountains (*Brandegee*, 1885), and about San Francisco, Cal. (*Vasey*, 1880, 545; *Mrs. Brandegee*, 1882; *Blankinship*, 1891). Others may consider this to be clearly distinct, but I leave it here for the present. *Kellogg & Harford*, 1868, 867, judging from a fragment in hb. Gray., may be the same.

b. Not glaucous: leaves mostly darker green, the lower broadly ovate or widest above the middle, undulate, sometimes cordate or abruptly rounded at base: inflorescence lax. — Plants two or three feet high.

15. R. Berlandieri, Meisner. — Erect or quickly ascending, glabrous to somewhat papillate; stem rather stout and succulent, mostly reddish, subsimple, zigzag above; leaves becoming 4 x 20 cm., spatulate to oblanceolate, obtuse; panicles terminal and axillary, leafless except for the main axis, the branches divergent or ascending; whorls dense, remote except above; pedicels rather stout, about as long as the fruit, tumidly jointed below the middle; valves 2.5 to 3 x 3 to 4 mm., subtriangular, erose or mostly with three or four very evident teeth on each side towards the base; callosities mostly 3, oblong, wrinkled on the sides below, unequal, the larger .7 mm. wide, extending beyond the middle of the valve; achene 1 x 2.3 mm. — DC. Prod. xiv. (1856), 45. — Arizona and New Mexico through Texas to Mexico. — Specimens examined from Arizona (*Palmer*, 1876, 638; *Evans*, 1891), New Mexico (*Wright*, 1851, 1781; 1852, 347, 1780), Texas (*Bound. Surv.* 1173; *Lindheimer*, 1843; *Vasey*, 1881; *Havard*, 1881, 111; *Miss Croft*, 115), and Mexico (*Mercier*, 1828, 115; *Berlandier*, 885, and 1831, 2315; *Palmer*, 1880, 1182). — Plate 27.

16. R. CONGLOMERATUS, Murray. — Mostly clustered, slender stemmed, glabrous; leaves not over 5 x 10 cm., ovate or mostly oblong, frequently somewhat fiddle shaped, obtuse; flowering branches slender, at length elongated; not zigzag, ascending, bearing a broadly lanceolate leaf at nearly every node; whorls dense, very remote except at ends of branches; pedicels rather slender, about as long as the fruit, tumidly jointed near the base; valves 1.5 x 2.5 mm., nearly oblong, obtuse; callosities mostly 3, round to ovoid, very prominent, smooth except for the sides below, where they pass into the larger veins, half as long and nearly as wide as the valves; achene 1.5 x 2 mm. — Prod. Fl. Goetting. (1770), 52; Meisner, DC. Prod. xiv. 49.— A European plant introduced sparingly along the Atlantic Coast, and abundantly in California.— Specimens examined from Virginia (*Curtiss*, 1872; *Dep. Agr.*, 1878), South Carolina (*Ravenel*), and various parts of California (*Palmer*, 1875; *Rothrock*, 1875, 64; *Parry* and *Lemmon* 1876, 372; *Greene*, 1876, 970; *Hooker* and *Gray*, 1877; *Nevin*, 1878; *James*, 1879; *Vasey*, 1880, 546; *Mrs. Brandegee*, 1891; *Blankinship*, 1891),—and ballast at New York (*Brown*, 1879, 12). — Plate 28.

R. SANGUINEUS, L.— Habit and general appearance of the last, but the slender flowering branches leafless, and one only of the valves with a large round callosity; veins of leaves, etc., typically very red.— Sp. i. (1753), 334; Meisner, DC. Prod. 49.— An occasional waif in the Atlantic region, seen by me only from ballast at Philadelphia (*Martindale*, 1880).— A form destitute of the red veining (var. *viridis*, Smith) from Tuscaloosa, Ala. (*Smith*, 1876), and on ballast near Phildelphia (*Martindale*, 1878), and at N. Y. City (*Brown*, 1879, 15).

This species was described by Linnæus as from "Virginia," but there is little doubt that it is a native of Europe. What has frequently passed for it in this country is the red-veined variety of *R. obtusifolius*, which is readily

recognized from its large ovate leaves not at all constricted above the base, and its large strongly toothed valves, much longer than the callosity.

** Valves very prominently toothed.

17. R. PULCHER, L.—A couple of feet high; stem rather slender but firm, zigzag above, branching at nearly every node or at length dichotomous above, mostly glabrous; leaves not over 5x12 cm., minutely crenulate crisped, fiddle shaped, cordate, obtuse to acute, the petiole and one or both surfaces of the principal veins mostly very papillate or subvillous; flowering branches simple, divaricate, all but their lowest leaves very small; whorls dense but remote; pedicels very stout, scarcely larger than the fruit, tumidly jointed in the middle; valves rigid, one commonly larger than the others, heavily veined, 3 to 4x5 mm., ovate, obtuse, with 5 to 10 stout teeth on each side, the short apex more or less erose; callosities frequently solitary, 1 mm. broad, half as long as the valve, wrinkled and often crested; achene 1.5x2.5 mm.—Sp. i. (1753), 336.—From the Mediterranean region, introduced in dry ground along the Atlantic Coast, especially southwardly, and on the Pacific slope.—Specimens examined from Virginia (*Morong*, 1877; *Seaman*, 1877; *Chickering*, 1878; *Vasey*, 1878, 421), Charleston, S. C. (*Hexamer* and *Maier*, 1855, 22), Mobile, Ala. (*Mohr*, 1871, 1890), Florida (*Chapman*), Pointe à la Hache, La. (*Langlois*, 1883), Nevada (*Engelmann*, 1880), Oregon (*Howell*, 1887, 712), and California (*Torrey*, 1865, 422; *Palmer*, 1876, 460 in part; *Hilgard*, 1891; *Blankinship*, 1891). Ballast specimens also from New York (*Brown*) and Camden, N. J. (*Parker*, 1879; *Martindale*, 1879, 1880.)—Plate 29.

18. R. OBTUSIFOLIUS, L.—Two or three feet high, erect; stem usually and sometimes strongly papillate; leaves somewhat undulate, ample or the lowest very large, broadly ovate, cordate, frequently acute, the often purple veins papillate, especially beneath; flowering branches sub-erect,

sparingly leafy below; lower whorls loose and rather remote; pedicels slender, about twice as long as the fruit, tumidly jointed toward the base, valves flexible, not very heavily veined, 2 to 3x4 to 5 mm., ovate-oblong, with 3 to 5 thin triangular teeth on each side, mostly confined to the lower half or two-thirds, the triangular entire apex mostly acute; callosities smooth, ovoid, scarcely reaching the middle of the valve, the largest one about 1 mm. broad, the other two usually very small; achene 1.3x2.2 mm.— Sp. i. (1753), 335; Meisner, DC. Prod. xiv. 53.— Roadsides, pastures, etc., everywhere in the East; introduced from Europe. — Specimens examined from points in Canada, Maine, Massachusetts, New York, New Jersey, Delaware, District of Columbia, Virginia, North Carolina, Florida, Louisiana, Pennsylvania, Ohio, Michigan, Wisconsin, Illinois, Tennessee, Iowa, Missouri, Kansas, Idaho, Arkansas (*Bigelow* on Whipple's Exped.), Texas, (*Reverchon*, 1874), Oregon (*Kellogg* and *Harford*, 1869, 869). — Plate 30.

Var. DISCOLOR, Wallroth, with the stem purple and the leaves very red veined, like beet leaves, is only an extreme color form often not distinguishable in herbarium specimens. What is probably that, examined from Nova Scotia (*Macoun*, 1883), Vancouver Island (*Macoun*, 1887) and California (*Kellogg*, 1866). This appears to comprise the greater part of the *R. sanguineus* of American collectors.

A hybrid of *obtusifolius* with *crispus* occurs quite frequently about St. Louis (*cf.* Meisner, DC. Prod. xiv, 54), intermingled with the parent forms or in the vicinity of one or the other. From the first, it differs in the decided blue green color of the leaves, the somewhat greater undulation of their margin, and the narrower outline of all but the lowermost, and in its variable fruiting valves being of unequal size, often broader than long, the lower two-thirds abruptly dilated and with 4 to 5 short acute teeth on each side, often unequally grown together, the three valves bearing prominent callosities. From *crispus* it differs in the more compound and lax panicle, broader lower leaves, and

deltoid or almost 3-lobed sharply toothed valves. It is found also in other localities, and may usually be recognized from a distance owing to the ragged appearance of the inflorescence, only a small percentage of the flowers enlarging (and fewer yet developing seed), so that the fruiting valves appear abnormally large by contrast, while they persist after the falling of the undeveloped flowers.

So far as I can determine, this is *R. acutus*, L. = *R. pratensis*, M. & K., which occurs throughout northern Europe (where it is often sterile), and is now generally admitted to be a hybrid of the two species named. Related but distinguishable hybrids are the Scandinavian *R. conspersus*, Hornem., *R. platyphyllos*, F. W. Aresch., and *R. propinquus*, J. E. Areschoug, — on all of which see F. W. Areschoug in Öfvers. K. Vet. Akad. Förh., 1862, 57–76 with plate 3. American specimens have been examined from numerous localities in and about St. Louis, Mo., Belleville, Ill., North Manitou Isl., L. Mich. (*Mrs. Wislizenus*), Ithaca, N. Y. (*Dudley*, 1883, 114), Amherst, Mass. (*Jesup*, 1871), and Washington, D. C. (*Ward*, 1884).— Plate 31.

19. R. PERSICARIOIDES, L. — Annual, a span to mostly a couple of feet high, slender to thick but soft stemmed, the larger plants branching from the base and often prostrate and rooting at the nodes, soon fistulous, subglabrous to mostly papillate-villous; leaves pale green, usually undulate, the largest 3x18 cm., lanceolate, mostly acute, the base commonly truncate, rounded or subcordate, papillate beneath on the principal veins; panicles leafy, axillary and terminal, the very dense whorls crowded to quite remote; pedicels capillary, scarcely twice as long as the fruit, tumidly jointed at base; valves 1.5x2.5 mm., equalled in length by the 2 or 3 bristle-form teeth on each side, the apex acutely produced but not bristle tipped; callosities 3, subequal, smooth, .3 to .4 mm. broad, compressed from the sides, nearly as long as the body of the valve; achene .6x1.2 mm.— Sp. i. (1753), 335. — *R. maritimus* of most recent

writers on American botany. — Wet sand along the sea-coast of the northern Atlantic States, about salt springs at various points in the interior, and on river banks, beaches, etc., across British America, extending southward to Illinois, southern California and Mexico.—Specimens examined from various points in British America, and from Massachusetts, Rhode Island, New Jersey, Wisconsin, Illinois, Iowa, Nebraska, Dakota, Montana, Idaho, Yellowstone Park, Colorado, New Mexico, Nevada, California, Oregon and Washington. — Plate 32.

The usual form, with narrow collosities and much elongated bristles, differs from the European *R. maritimus* only in the frequent wavy margin and obtuse base of the leaves and the occasional development of a third bristle on each side of the valves; and a few sea-shore specimens apparently belong to the normal form of the latter. If it is kept apart from the European plant, it must bear the name here employed, and I am inclined to think that it is as distinct as most Old World species of the *maritimus* group. But in any event, if precedence on a given page is held to establish the priority of one name over another, *persicarioides* has precedence over *maritimus*.

R. crispatulus, Michx., Fl. i. (1803), 217, is the form with broadest most wavy leaves, more naked inflorescence, and larger valves, only two of them bearing unequal callosities; but a study of the many forms growing intermingled about St. Louis, has not shown the wisdom of maintaining it even as a variety.

A specimen from Washington (*Suksdorf*, 1889, 943), has nearly entire valves, but the usual form occurs under the same number; and a very similar plant is *R. salicifolius*, var. (?) of Watson, Bot. King. 314, from Nevada (*Watson*, 1868, 1052).

R. BUCEPHALOPHORUS, L. — Annual, a span or two high, spreading, slender, simple or with few subequal branches, glabrous and apparently somewhat glaucous; leaves scarcely

1.5x2 cm., rhombic ovate to oblanceolate, obtuse to acute, cuneate, not wavy, reduced and ultimately obsolete on the branches; flowers in the upper axils, forming slender spike-like racemes, few in a whorl; pedicels once or twice as long as the fruit, at length much dilated and involute above so as to appear clavate, jointed below the middle, frequently papillate; outer sepals rather large, reflexed or arcuately spreading; valves 1x2 mm., somewhat 3-nerved, with a few transverse veins, acute or acutish, with about 3 broad hooked teeth on each side; callosities 3, minute, basal, acute margined; achene .7x1.3 mm.— Sp. i. (1753), 336; Steinheil, Ann. Sc. Nat. 2 ser. ix. 193, pl. 7; Meisner, DC. Prod. xiv. 62.— A Mediterranean species of somewhat the habit of *Acetosa*, represented by a single collection from Louisiana (Port Eads, May 6, 1885, *Langlois*, no. 95 and 134). — Plate 33.

EXPLANATION OF PLATES ILLUSTRATING THE NORTH AMERICAN SPECIES OF RUMEX.

The figures were drawn, under supervision of the author, by Mrs. J. C. Duffey and Miss Grace E. Johnson, whose signatures indicate the plates drawn by each. Nos. 13, 14, 22, 23, 25, 28, 30, 31 and 32 are from living plants; the remainder, from herbarium specimens. Illustrations of fruit are from drawings by the author.

Plate 13, *R. Acetosella* L.— Rather large plant, reduced to half size; and fruit, inclosed in calyx, x 8.

Plate 14, *R. hastatulus*, Baldw.—Staminate and pistillate plants, half size; fruiting branch, natural size; fruit, x 4; achenium, x 8.

Plate 15, *R. Geyeri* (Meisn.).— Staminate and pistillate plants, one-sixth size; leaves and fruiting branch, natural size; fruit, x 4; achenium, x 8.

Plate 16, *R. Acetosa*, L.—Staminate and pistillate plants, one-sixth size; leaf and fruiting branch, natural size; fruit, x 4; achenium, x 8.

Plate 17, *R. venosus*, Psh.— Habit, one-sixth size; leaves and fruit, natural size; achenium, x 8.

Plate 18, *R. hymenosepalus*, Torr.— Roots and habit, one-sixth size; leaf, half size; fruit, natural size; achenium, x 8.

Plate 19, *R. occidentalis*, Wats.— Habit, one-sixth size; leaf, half size; fruiting branch, natural size; achenium, x 8.

Plate 20, *R. Patientia*, L.— Habit, one-sixth size; leaf, half size; fruiting branch, natural size; achenium, x 8.

Plate 21, *R. Britannica*, L.— Habit, one-sixth size; leaf, half size; fruiting branch, natural size; fruit, x 4; achenium, x 8.

Plate 22, *R. crispus*, L.— Habit, one-sixth size; leaf,

half size; fruiting branch, natural size; fruit, x 4; achenium, x 8.

Plate 23, *R. verticillatus*, L. — Habit, one-sixth size; root and leaf, half size; fruiting branch, natural size; fruit, x 4; achenium, x 8.

Plate 24, *R. Floridanus*, Meisn. — Habit, one-sixth size; leaves, natural size; fruit and achenium, x 8.

Plate 25, *R. altissimus*, Wood. — Habit, one-sixth size; leaf, half size; fruiting branch, natural size; achenium, x 8.

Plate 26, *R. salicifolius*, Weinm. — Habit sketches, one-sixth size; leaf, half size; fruiting branch, natural size; two fruits and achenium, x 8.

Plate 27, *R. Berlandieri*, Meisn. — Habit, one-sixth size; leaves, half size; fruiting branch, natural size; fruit and achenium, x 8.

Plate 28, *R. conglomeratus*, Murr. — Young plant, one-sixth size (the branches become much more elongated and spreading); leaf, half size; fruiting branch, natural size; fruit and achenium, x 8.

Plate 29, *R. pulcher*, L. — Habit of young and old plants, one-sixth size; leaves, half size; fruiting branch, natural size; fruit and achenium, x 8.

Plate 30, *R. obtusifolius*, L. — Habit, one-sixth size; leaf, half size; fruiting branch, natural size; fruit and achenium, x 8.

Plate 31, *R. crispus* x *obtusifolius* (*R. acutus*, L). — Habit, one-sixth size; leaf, half size; fruiting branch, natural size; two fruits, x 4.

Plate 32, *R. persicarioides*, L. — Habit, one-sixth size; leaf, half size; fruiting branch, natural size; fruit and achenium, x 8.

Plate 33, *R. bucephalophorus*, L. — Habit, half size; leaves and fruiting branch, natural size; fruit and achenium, x 8.

INDEX TO SPECIES OF RUMEX.

Synonymes in parentheses.

RUMEX ACETOSELLA.

RUMEX HASTATULUS.

RUMEX GEYERI.

RUMEX ACETOSA.

RUMEX VENOSUS.

RUMEX HYMENOSEPALUS.

RUMEX OCCIDENTALIS

RUMEX PATIENTIA

RUMEX BRITANNICA.

RUMEX CRISPUS.

RUMEX VERTICILLATUS.

RUMEX FLORIDANUS.

RUMEX ALTISSIMUS.

RUMEX SALICIFOLIUS.

RUMEX BERLANDIERI.

RUMEX CONGLOMERATUS.

RUMEX PULCHER.

RUMEX OBTUSIFOLIUS.

RUMEX OBTUSIFOLIUS × CRISPUS.

RUMEX PERSICARIOIDES.

RUMEX BUCEPHALOPHORUS.

THE YUCCA MOTH AND YUCCA POLLINATION.

BY C. V. RILEY, PH. D.

PART I.

Introductory.

Twenty years have nearly passed since the first announcement of the method of pollination of our Yuccas by the little white Lepidopteron which I christened *Pronuba yuccasella*. The curious facts connected with its structure and life habits and its intimate relation with the Yuccas; the ease with which it is confounded with the Bogus Yucca Moth, found in the same flowers, but possessing no power of pollination; the confusion which the facts have caused in the minds of other observers; the criticism and discussion which have followed the observations; and the opinions of others, often based on erroneous observations and conclusions — have resulted in a number of articles, scattered through a number of publications. My friend, Professor Trelease, has repeatedly urged me to put together a consecutive statement of the facts in the case, feeling that such a statement would prove useful to botanists and entomologists alike. It would seem, indeed, eminently appropriate to publish such a recapitulation in the Annual Report of the Missouri Botanical Garden, in which, while its founder was still living, many of the original observations, both by Engelmann and myself, were made.

The present article will fall, naturally, into two parts, the first a more popular recapitulation of the facts in reference to *Pronuba yuccasella* and Yucca pollination, in which will be repeated, almost verbatim, the earlier accounts as given in the third volume of the Transactions of the St. Louis Academy of Sciences and in my Fifth and Sixth Reports on the insects of Missouri, and elsewhere. In the

second portion will be transcribed from my notes some unpublished details not only in reference to this particular species but to other species of the family Prodoxidæ to which it belongs.

FERTILIZATION OF PLANTS GENERALLY.

The common belief, based upon the theological assumption that all things upon this terrestrial sphere are for man's especial benefit, was, and perhaps yet is, that flowers were endowed with beauty and fragrance for our particular pleasure. Let us look somewhat more closely into this matter, and see what modern science has to say about it. Ever since Linnaeus used the sexual characteristics of flowers in classification, and Erasmus Darwin sang of the loves of the plants, the philosophy of fertilization in the plant kingdom has been fairly apprehended. It has long been recognized that plants are divisible into homomorphic or self-fertilisable, and heteromorphic or cross-fertilisable species. All diclinous plants, or those having separate male and female flowers, belong to the latter category, which is further classifiable according to the means by which cross-fertilization is effected. One class (termed anemophilæ) depend almost entirely on the wind, and in these, of which our pines and other conifers, our poplars, willows, grasses, etc., are examples, the pollen or male element obtains in enormous quantities, is easily detached, and is generally produced early in spring, when winds prevail, and frequently before the development of the leaves, which would tend to impede its dispersion. The flower is inconspicuous and the stigma or female organ generally branched or hairy, so as to increase the chance of catching the wind-borne pollen. Water is an agency in the fertilization of a few plants, of which the singular Vallisneria is a striking illustration; while a few are aided by birds and higher animals; but by far the greater number are fertilized, or more strictly speaking, pollinized, by insects.

The most casual observer of nature must have appreciated, years ago, the fact that flowers are very important to insects, furnishing the essentials of life to those of several orders and especially to the Hymenoptera (Bees, Wasps, etc.) and Lepidoptera (Butterflies and Moths) in the form either of pollen or nectar. But that insects could be of any especial benefit to plants has only come to be acknowledged and fully appreciated of late years. Toward the close of the last century Christian Konrad Sprengel published an important work — Das Entdeckte Geheimniss der Natur — in which he maintained that the color, form, odor, secretions, and the general structure of flowers had reference to insects which are essential as pollinizers. The importance of insects as agents in cross-fertilization was scarcely appreciated, however, until the late Charles Darwin published the results of his researches on Primula, Linum, Lythrum, etc., and his elaborate work on the fertilization of orchids. The publication of these works gave to flowers a new significance and to their study almost as great an impulse as did his immortal "Origin of Species" to the general study of biology. Hooker, Bennett, Axell, Delpino, Hildebrand, Hermann Müller, and others abroad, and Dr. Gray and Mr. William Trelease in this country, have followed up this subject; and no one can familiarize himself with the results of their studies without a keen sense — if not a conviction — that in the vast number of cases Sprengel's early statement holds strictly true. By these deeper insights into the significances of the floral world, and their harmonies with the insect world, we learn to understand why night-blooming flowers are usually white, even where their day-blooming allies are brightly colored, as in the case of *Lychnis vespertina* and *L. diurna;* or why the calyx, which is usually hidden and green, becomes bright when exposed, as in the Berberry and Larkspur. Many flowers are known to close or "sleep," and while most of them follow the animal world in taking this rest at night, yet there are marked excep-

tions. The dandelion goes to rest at 5 p. m., and wakes at 7 a. m., while the popular names of "4 o'clock" and "John-go-to-bed-at-noon" sufficiently indicate the sleeping hours of Mirabilis and Tragopogon. Sir John Lubbock tritely asks "What is the meaning of sleep in flowers, if it is not in reference to insects?" The closing during those hours when the particular insects needed for pollination are at rest, would protect the flower from spoliation by useless raiders. This belief is also strengthened by the fact that anemophilous flowers or those fertilized by the wind, never sleep, and that flowers which attract insects by smell, emit their odor at particular hours.

But the most interesting fact not commonly understood, that has now been very fully established by the most thorough researches, is, that a very large number of plants, even where the sexes are united in the same flower, absolutely depend on insect aid for pollination, and that the contrivances to induce cross-fertilization are infinite in diversity, while the modifications in structure which these insects have undergone the better to fit them to perform this service, are equally remarkable.

In Dr. Asa Gray's little work, "How Plants Behave," etc., instances enough are given, in an admirably plain and lucid style, to show the manner in which many flowers are curiously and elaborately constructed so as *just not to do* of themselves what must necessarily be done for them in order to prevent degeneracy or extinction of the species. Some plants, as Fritz Müller proved, are so self-impotent that they never produce a single seed by aid of their own pollen, but must be fertilized by that of a supposed distinct species, or even of a supposed distinct genus; while in some cases the pollen and stigma mutually act on each other in a deleterious manner. In most of these entomophilous plants fructification may be brought about by the aid of more than one species of insects, and few plants offer a more striking instance of dependence or more curious floral mechanism to allure, than do the orchids. In

the genus Habenaria, for instance, we find flowers which in some cases strongly resemble butterflies; a separate pocket for the nectar; the pollen bound together in masses by elastic threads, so as to lessen the chance of loss; the base of the stamens forming flattened sticky discs placed in the best possible position for adhering to the head-parts of a moth endeavoring to reach the nectar. In all these features and others that might be mentioned, there is remarkable adaptation; and the flowers of many orchids, as they unfold, seem not only to invite but to court and crave the intervention of some scaly-winged marriage-priest "of glorious color and glistening eye," who shall at once procure a suitor and perform the nuptials. Yet here we have the adaptation of the plant only, and except in a few instances, as, for instance, in that Madagascar orchid, *Angraecum sesquipedale*, where the nectary is so deep that its nectar can be reached only by a moth (like *Macrosila cluentius*) with a very long tongue, our orchids are not dependent for pollination on any one Lepidopterous species, but may be aided by many which have tongues of sufficient length.

CONNECTION OF YUCCA AND PRONUBA.

There are, in fact, few plants which are dependent on a single species for pollination. So far as I know, the Yuccas furnish the only instance of this kind, for they actually depend on some particular species of little white moths belonging to the Tineina and to the genus Pronuba. The Yuccas are a very interesting genus of lily-like plants, so familiar to everyone in our public and private gardens that I need not say very much about them. There are numerous species and even sub-genera, but they are all characterized by anthers not reaching anywhere near the stigma, so that fertilization unaided can take place only by the merest accident. In other words, the stigmatic tube is nowhere within reach of the stamens, and the pollen either remains attached to the open and withered anthers or falls and

remains in different sized lumps on the inside of the perianth, and cannot be introduced into the stigmatic tube without artificial aid.

Our commoner garden Yuccas, forms of *filamentosa*, depend on the commoner Yucca moth, *Pronuba yuccasella* (Pl. 34, Fig. 1, *b. c.*) and so do all the different species found east of the Rocky Mountains, so far as we yet know. During the day-time we may, by knowing what and where to seek, often find this moth either singly or in pairs, resting with folded wings within the half-closed flowers. It is then not only hidden from ordinary view, but well protected by the imitative color of the front wings with that of the flower, so that close scrutiny is necessary for its detection. If we visit the plant after

> " * * * the garish day
> Has sped on his wheels of light away "

and when, with full-blown perianth, the Yucca stands in all her queenly beauty, and sends forth her perfume more strongly upon the night air, we shall, with a little patience, meet with this same moth, flitting swiftly from flower to flower and from plant to plant — the dusky nature of the hind wings and of the undersurface of the front wings almost completely offsetting and neutralizing, when in motion, the upper silvery whiteness of the latter, and thus still rendering the insect a little difficult of detection. It is principally the male which we thus see flying and, by the aid of a " bull's eye," we shall find the female for the most part busily at work in the flowers. He, with relatively stronger wing-power, can afford to spend in the most pleasurable way the few brief days allotted to him; but *she* is charged with a double duty and loses little time in its performance. As a part of the maternal task of continuing her race, she must act as foster-mother to the plant in order to ensure a proper supply of food to her larvæ, which, as we shall presently see, feed on its seeds.

STRUCTURAL CHARACTERISTICS OF PRONUBA.

As preliminary to a better understanding of the habits of the female, it will be well to draw attention to those structural peculiarities which distinguish her from all other species of her order and which so admirably fit her for the work she has to do. Pl. 34, Fig. 3 gives some details of the head (*a*) and an important structure which more particularly characterizes her and interests us, is the maxillary tentacle shown with its palpus at *b*. She has a pair of these organs, which are prehensile and spinous, and it is chiefly by means of these that she is able to collect and hold a relatively large load of pollen for the purpose of pollination. Another organ which is characteristic is the ovipositor. When this is entirely withdrawn, the tip of the abdomen presents a truncate appearance, the terminal joint being bluntly rounded at the tip with a slight projection both above and below and with a corrugated ridge dorsally a little in advance of the tip. This terminal joint is very much compressed from the sides, with a few stiff hairs around the terminal border. The ovipositor issues from the middle of the truncate end and when critically examined the basal part, when highly magnified, shows an imbricato-granulate surface, the granulations strongest basally and diminishing distally, while the terminal part is smooth, long, and peculiarly constructed at the tip, the extreme tip being notched or serrate and having a dorsal fin also finely and sharply serrate, running anteriorly from it—the whole recalling in form the caudal and second dorsal fins of the Lamprey (Petromyzon). It thus presents itself, as usually exserted when the moth is quickly killed while in the act of oviposition; the imbricate basal and smooth terminal parts looking like two joints, while the protruded portion of the vagina looks like a third and short basal joint. The various details shown in Plate 37, Fig. 1 will help to elucidate the nature of this organ. Ventrally along the terminal part is seen a membranous duct which broadens just

in front of the tip and has an outlet from which a soft, extensile oviduct can be extruded. This is fine, silk-like, pale, membranous and very elastic. It is smooth basally but armed along its terminal third with retrorse hairs, increasing somewhat in number and strength toward the tip, around which they are almost spinous. At first sight these would seem to be out of place and to impede rather than aid the insertion of such a delicate filament; but as we shall presently see the act of oviposition is a most intricate and difficult one and these hairs are doubtless sensitive and tactile and serve the double purpose of enabling the moth to feel her way in the ovarian cell and of temporarily anchoring in the soft wall thereof, while the egg is being passed to its destination. The manner in which this remarkable ovipositor is worked by chitinous rods with muscle attachments will be considered in a fuller statement of the internal anatomy of the moth in the second part of this paper. My purpose here is to call attention simply to those features which will more fully explain her visible acts, and it will be seen that this ovipositor is admirably adapted for cleaving through the young fruit and then running the egg into the ovarian cavity, as will be presently described. The male has no very marked characteristics and is distinguished from allied species chiefly by the structure of the exposed horny parts of the genitalia at the tip of the body. (Pl. 37, *r. s.*).

THE ACTS OF POLLINATION AND OVIPOSITION.

Though all the acts of the female are nocturnal, it is not at all difficult to follow them with a lantern, for, albeit ordinarily shy, she may be closely approached when she is about to oviposit. Her activity begins soon after dark, but consists, at first, in assiduously collecting a load of pollen. She may be seen running up to the top of one of the stamens, and bending her head down over the anther, stretching the maxillary tentacles, so wonderfully modified for the purpose, to their fullest extent, the tongue uncoiled

and reaching to the opposite side of the stamen. In this manner she is able to obtain a firm hold of the stamen while the head is kept close to the anther and moved peculiarly back and forth, something as in the motion of the head of a caterpillar when feeding. (Pl. 38, Fig. 2). The maxillary palpi are used in this act very much as the ordinary mandibles are used in other insects, removing or scraping the pollen from the anthers toward the tentacles. After thus gathering the pollen, she raises her head and commences to shape it into a little mass or pellet by using her front legs very much as a cat does when cleansing her mouth, sometimes using only one leg, at another time both, smoothing and pressing the gathered pollen, the tentacles meanwhile stretching and curving. After collecting all the pollen from one anther, she proceeds to another and repeats the operation, then to a third and fourth, after which, with her relatively large load — often thrice as large as the head — held firmly against the neck and front trochanters, she usually runs about or flies to another plant; for I have often noticed that oviposition, as a rule, is accomplished in some other flower than that from which the pollen was gathered, and that cross-fertilization is thus secured.

Once fully equipped with this important commodity, she may be seen either crawling over or resting within the flower, generally with the head toward the base. From time to time she makes a sudden dart and deftly runs around the stamens, and anon takes a position with the body between and the legs straddling two of them, her head being usually turned toward the stigma. As the terminal halves of the stamens are always more or less recurved, she generally has to retreat between two of them until the tip of her abdomen can reach the pistil. (Pl. 37, Fig. 2). As soon as a favorable point is reached, generally just below the middle, she rests motionless for a short time, when the abdomen is slightly raised and the lance-like ovipositor is thrust into the soft tissue, held there the best part of a

minute, while the egg is conducted to its destination, and then withdrawn by a series of up and down motions.

In non-technical language, the pistil or the young fruit, below the stigmatic tube, shows externally at this time six quite distinct longitudinal divisions each having a median ridge, there being six corresponding depressions or concavities in which the six stamens fit, especially at the base. Technically, the pistil is a three-celled ovary, the styles bifid at tip and united so as to form the stigmatic tube. A transverse section anywhere about the middle will show that each of the six longitudinal sections contains a row of ovules within the ovarian cell. More strictly, the ovules are in pairs, as there are but three primary sections or carpels, divided by three primary divisions or dissepiments. Pl. 36, Fig. 1, shows a transverse section of one of these primary divisions or carpels which well indicates the position of the ovule (*a*) the funiculus (*b*), the placenta (*c*), and the ovarian cell (*d*). As the fruit enlarges the three secondary dissepiments narrow and coalesce, while the other three widen, so that the pod becomes practically three-lobed and the seeds are more distinctly in pairs, the inner side straight and the external quite convex. In oviposition the young fruit is pierced just within the ridge in the depression occupied by the stamens, and almost always on the side of one of the primary or deeper divisions, where the walls are thinnest, so that the ovipositor enters the ovarian cell at the external or rounded side of an ovule, and does not ordinarily touch the ovule itself. (Pl. 36, Fig. 2, *aa*). Rarely, however, the ovipositor penetrates the ridge and passes between two of the ovules, or sometimes even penetrates one, this last case being, however, quite exceptional.

During the insertion of the egg, which, as stated, usually occupies about one minute, a nervous twisting and trembling of the body may be observed, and so intent is the moth upon this work that after the ovipositor once penetrates the pistil, the whole perigon may be detached, some of the encumbering stamens and petals removed, and the insect

brought within the range of a good lens, when all her movements may be observed to the greatest advantage without disturbing her. In this way I have been able to watch the consignment of hundreds of eggs, and to admire the delicacy and elasticity of the oviduct proper, which issues from the chitinous sheath in a silk-like thread, almost invisible to the naked eye. While being withdrawn it is seen to be as long as, or longer than, the terminal abdominal joint and stretches or bends as the body is raised or lowered, in freeing it from the pistil. Indeed this freeing is a laborious job, and occupies from forty seconds to two minutes. Oviposition rarely begins before dusk, and takes place only in the flowers which are newly opened, *i. e.*, during the first or second nights after opening, as it is chiefly during these nights that the ovary is susceptible to pollination, the stigmatic tube and the ovules, which are at first open for the reception of the pollen, thereafter closing. The moth seems instinctively aware of this and is never found ovipositing in the older flowers. Indeed, her actions indicate that she investigates closely not only the condition of the pistil as to development, but as to whether or not it has already been punctured.

It may be well here, in order to more fully understand the action and influence of the moth, to look a little more closely into the characteristics of the Yucca flower at this stage of its development. A longitudinal section of the upper portion of the pistil will show us the style with its stigmatic tube, which, at this time, communicates with the ovarian cells. Trelease (who will, I hope, accompany this article with some botanical details showing the pollen tubes and other microscopic structures) has shown that the stigmatic liquor is not nectarian, but that the slight amount of nectar which is associated with the flowers, is secreted in thin pockets formed by partitions that separate the three cells of the pistil and which open externally by a contracted pore from which the nectar is poured through a capillary tube (enclosed by the closely applied but not outwardly

united lobes of the ovary) to the base of the pistil, so that nectar-feeding insects seek it, not about the stigma, but at the base of the stigma or of the petals, whether within or without. I have fully verified Trelease's statements by dissection of the pistil and by study of the insects seeking this scant nectar and endorse his conclusions, that, while the observations serve to disprove any positive value of their nectar in the pollination of the Yucca flowers, they add to the importance of Pronuba by showing that the acts of collecting pollen and transferring it to the stigma do not result in any food compensation, as I was at first inclined to suppose. In other words, there is no nectar to allure other nectar-loving insects and cause them to go to the stigma; but on the contrary, those which are drawn to the plant by the slight amount of nectar are led in the very opposite direction, viz., to the base of the style or of the flower. It is also an interesting fact that I have never noticed Pronuba feeding, as contradistinguished from pollinizing, for the motions of the tongue of Lepidoptera when feeding are quite characteristic and easily recognized. Indeed the two pieces which form the tongue are so often separated at tip, and so weakly joined throughout, as to raise the question, in connection with a somewhat imperfect alimentary canal, as to whether the moth feeds at all, and to suggest that the rather strong tongue, otherwise, assists pollination.

No sooner is the ovipositor withdrawn into the abdomen than the moth runs up to the top of the pistil, thrusts the pollen into the stigmatic opening, and works her head rapidly — the motion being mostly up and down and lasting several seconds. She works with a vigor that would indicate combined pleasure and purpose and makes every effort to force the pollen into the tube, thrusting it ordinarily from the base of one of the three primary clefts of the style. In my earlier observations I had always supposed that the tongue was used, in this operation, for sipping the liquid from the stigma after, or in connection with, her more

arduous work; but it is probable that, seeing that this liquid is not nectarian, Professor Trelease is right in stating that the tongue is used to thrust the pollen further into the cavity than her tentacles can reach, though I can see no necessity for this action so far as pollination is concerned. After the more vigorous motions of thrusting the pollen into the tube, she frequently rests in comparative quiet, working her tongue in the tube sometimes for four or five minutes together, but ordinarily the act of pollination ceases with the few vigorous thrusts already described. The importance of this act will be better appreciated when I state that numerous experiments in artificial or brush pollination have shown that effective fertilization in *Yucca filamentosa* is by no means an easy matter, and that it rarely takes place as effectively as through the actions of Pronuba.

This carrying of the pollen to the stigma generally follows every act of oviposition, so that where ten or a dozen eggs are consigned to a single pistil, the stigma will be so many times be-pollened. The ends of the tentacles, which are most setose and spiny, and which are always curled into the pollen mass when not uncoiled, must necessarily carry a number of pollen grains into the stigmatic tube each time pollination takes place; and I have noticed a gradual diminution in the size of the collected mass, corresponding to the work performed, which is indicated by the rubbed and worn appearance of the individual, the freshest specimens always having the largest loads. I have also noticed that where oviposition occurs thrice in the same pistil (and this is most common), the three corresponding acts of pollination are consecutively in the three deeper notches of the style, thus insuring a supply for the ovules in each carpel. Pollen collecting is, however, sometimes continued after oviposition has begun, but is rarely witnessed during the active period of egg-laying. This is, however, invariably followed by pollination, though not always alternating therewith. Indeed it is not uncommon for a female

to consign two or three eggs to the same pistil, before running up to the stigma and inserting the pollen.

While oviposition generally takes place in the manner described, the moth head outward (Pl. 37, Fig. 2) and straddling two stamens, the opposite position is sometimes assumed, and larvæ and punctures are not infrequently found in the upper part of the fruit, especially where a single fruit is stocked with ten or more larvæ. As the fruit enlarges, the mouth of the puncture forms a slight discolored depression, more noticeable in some varieties than in others; but the passage-way becomes obliterated.

DEVELOPMENT OF THE EGG AND LARVA: TRANSFORMATIONS OF PRONUBA.

The egg is an extremely delicate, thread-like structure, averaging 1.5 mm. in length and less than 0.1 mm. (Pl. 37, fig. 1, *m*, *n*, *o*.) in diameter, tapering at the base and enlarging slightly toward the capitate end, which has also a slightly indurated point. * It is impossible to follow it with the unaided eye or in fact with an ordinary lens, even if the pistil be at once plucked and dissected; but by means of careful microscopic sections, we may trace its course. From the position assumed by the moth, the ovipositor punctures the pistil somewhat obliquely, but as the egg is much longer than the diameter of the ovarian cell, the delicate oviduct of the moth bends and then runs vertically along the inner part of the cell next the placenta, and leaves the egg extending in this longitudinal direction along some seven or eight ovules, as

* In the ovaries the less developed eggs are shorter and elliptical, as shown in my earlier figure (Proc. A. A. A. S. XXIX, Fig. 3, *h*.) and there is every gradation between this and the more mature ova which have the same filiform character as when seen in the Yucca pistil. It is interesting thus to note that the immature and undeveloped egg of Pronuba corresponds with the mature egg of Prodoxus.

shown in the illustrations (Pl. 35, Fig. 2, *c. c.*).* The apical end of the egg soon enlarges (Pl. 37, Fig. 1, *n*) and the embryo may be seen developing in it, very much as in the case of the similarly elongate eggs of gall-flies (Cynipidæ), though the pedicel does not shorten, as observed in these last. Segmentation is noticeable on the second day and the Yucca ovule at once begins to swell and enlarge, the irritation (doubtless mechanical) influencing the plant tissue much as in the case of the punctures of the gall-flies just mentioned. Sometimes two or more adjacent ovules are thus affected.

The larva hatches in about a week and will be found at a point from 8 to 10 ovules above or below the external puncture according as the egg was thrust above or below it. It is not more than 1 mm. long and seems to live for some time on the juices of the degenerate and swollen ovules, but finally enters one that is developing, at the funicular base. So far as I have observed, the larva undergoes some three different molts, as but four different sizes of the head have been noticed. The general color, which is at first translucent white, conforms for the most part to the color of the tissues in which it is feeding; but becomes in time more yellowish, and finally, when mature, ordinarily acquires a rosy hue. The larva has no pro-legs, but has well-developed thoracic legs. It matures with the ripening of the seeds, which differs in time in the different species of Yucca, and also in the same species, but occupies on an average about a month in the ordinary *Yucca filamentosa*. The number of seeds destroyed is rarely more than a dozen and more frequently less, and I have recorded the fact of

* The position and development of the egg were studied in 1874, by Engelmann and myself (Trans. Ac. Sc. St. Louis, III, pp. 208–211) and while the egg, from those observations, is sometimes curled around an ovule in the ovarian cell, the position above described is the normal position as subsequent study has shown. I also gave there the duration of the egg state as four or five days, but it more often extends beyond a week. I also there attributed the swelling of the ovules to the action of the larva, but it begins before this hatches.

having found as many as twenty-one larvæ in a single pod. Just about the time the pods are hardening and ready to dehisce and the seeds have already colored, the full-grown larva bores its way out of the pod, makes its way to the ground — in all probability by the aid of a silken thread — and there bores several inches below the surface and forms a tough silken cocoon intermixed with the soil. It makes its burrow to the extreme epidermis of the pod sometime before it leaves, and if there should happen to be a long spell of wet weather at this time, the burrow is very apt to become saturated with moisture and the larva to perish from mould. I have never seen one issuing during the day, or in the early part of the night, so that it probably leaves the pod late at night. It remains as a larva within its cocoon during the fall, winter and spring months and only transforms to the chrysalis state a few days before the blooming of the Yuccas. The chrysalis, (Pl. 34, Fig 4) as shown in the figure, is armed with an acute spine on the head and with singular spatulate spines on the back, which are well fitted to enable it to work its way to the surface from its underground retreat.

It thus works its way partly out of the ground and as this is generally under the shelter of the mass of Yucca leaves (in the case of our filamentose species) the issuing is rarely seen, except by the most careful watching. The newly-escaped moth, with wings crumpled and moist, runs up one of the leaves and hangs thus sheltered, while her wings expand, following the invariable rule of all the members of her Order, and throwing them first back together to facilitate inflation (Plate 34, fig. 2) and only closing them and folding them along the body after they have become sufficiently firm.

EFFECT OF PUNCTURE ON THE FRUIT.

The effect of the puncture of the female moth in oviposition is at once noticeable on the young fruit by a darker green discoloration externally. In time this becomes a

depression, and the irregularities of the pods (Pl. 34, Fig. 5, *b. c.*) which have been considered characteristic of the fruit of the genus are chiefly due to these punctures, which, ordinarily occurring just below the middle of the pod, produce a more or less marked constriction there. This I have often proved by artificially pollinizing the flowers and protecting them from Pronuba, when the pods will develop in a regular, parallel-sided manner (Pl. 34, Fig. 5, *a.*) Internally the effect of the puncture is no less marked. A few of the ovules in the region of the puncture are at once affected, as already described, while the development of a yet larger number is more or less arrested, this being the case even when not touched by the ovipositor or the egg, or even where the egg fails to hatch. Did the ovules develop immediately around the egg it is probable that they would crush it. At Pl. 35, Fig. 2 *d* is shown a section of a carpel 7 days old with egg, and of another, *e*, with the larva just hatched.

EFFECT OF FERTILIZATION ON THE STALK.

It is an interesting fact that, however pollinized, whether by Pronuba or artificially, each Yucca panicle will mature but a certain number of pods, so that a number of those which are fructified drop after a few days' development, while some wither even after they have reached nearly full development. This gives an element of uncertainty to experiments and makes it necessary to be very careful. It is interesting also to note how the mere fact of fructification influences the main stalk, at least in *Y. filamentosa*, for where a panicle is protected with gauze, so as to prevent the access of Pronuba, and cause the dropping of all the flowers, the stalk soon thereafter withers and dies.

DATES OF THE FLOWERING OF THE YUCCAS AND APPEARANCE OF THE MOTH.

There is some irregularity in the flowering of our Yuccas, even of those of the same species. The typical form of

Y. filamentosa at Washington and St. Louis begins blooming about the middle of June, and is usually through blooming about the middle of July. In Philadelphia, so near to Washington, it blooms nearly two weeks later. *Y. angustifolia* blooms from a fortnight to three weeks earlier, so that it has almost ceased to bloom before *filamentosa* begins. *Pronuba yuccasella* is restricted in its appearance in the imago state, and in the eastern portion of the country appears coetaneously with the flowering of *Yucca filamentosa*, the males almost always being seen first. Thus both at St. Louis and at Washington *Yucca angustifolia* does not ordinarily set fruit, because it flowers before the Yucca moth appears. Occasionally, however, this last is about when some of the latest or terminal flowers are open, and I have known a few pods on the tip of the panicle of this species to be fructified in St. Louis. So in the more northern States, where *Yucca aloifolia* is cultivated, it blooms too late to be pollinized, and I have never known it to set fruit.

In South Carolina, as Dr. J. H. Mellichamp informs me, there is even greater irregularity in the blooming of *Y. filamentosa*, though the genuine or more typical form blooms a month earlier than at Washington. This is pollinized by Pronuba; but some varieties bloom earlier or later — even in autumn. In these later bloomings Dr. Mellichamp has never known fruit to be produced. The variety *lævigata* usually blooms two weeks later, and the variety *bracteata* still later than the typical form.

Yucca aloifolia blooms in the south in June and July and the earlier blooming specimens are pollinized by Pronuba.

Yucca gloriosa flowers in the south still later (September and October) and rarely sets fruit. It is very irregular, however, and on one occasion Dr. Mellichamp found a plant blooming in June in an old sandy field. This was the only plant he ever saw blooming in summer, and it produced fruit. I have seen a form of it blooming in March, with no sign of fructification.

Further accurate and careful observations are very desirable as to the dates of appearance of Pronuba in the Gulf States region. The general result of my observations in the southern States as to the presence of the insect would indicate that its appearance is adapted there to the greater irregularity of the blooming of the Yuccas; but as a general thing, *Y. aloifolia* is seldom fructified except when blooming at the same time as *filamentosa*, and the same is true of *gloriosa*, which more rarely produces fruit.

No one can observe our Yuccas closely without noticing a certain irregularity in blooming. The same root-clump of *filamentosa* will some years throw up several flower-stalks and in other years none. This is particularly noticeable in the Rocky Mountain region, and the fact that the flowers of *Yucca brevifolia* are uniformly scarce over large stretches of country has been repeatedly observed and reported to me. I observed it on my first visit to these tree Yuccas in 1887 and I remember very well that of *Yucca angustifolia* — which is quite common on approaching Denver and was found all along the Denver & Rio Grande R. R. to Colorado Springs, growing even in the side-walks of that town — not a single flower-stalk was noticed when I first visited those parts in 1873. This irregularity in blooming would prove fatal to insects depending upon the flower and fruit, were there not some provision to meet it, and it is one of the noticeable characteristics of the Yucca moths that they are equally irregular in development; for, as we shall presently see, a very large percentage of the moths fail to issue the year following the development of the larva, but show a great tendency to retardation in development, some of them not issuing until the second, third or fourth year. This is equally true of both Pronuba and Prodoxus.

NEED OF PRONUBA.

We have already seen that all the pods do not contain Pronuba larvæ, though we rarely find any on the fila-

mentose species that do not show the marks of puncture, which indicates that a great many punctures are fruitless in result, owing either to the difficulty of the operation of oviposition, or to the fact that the eggs, having been once consigned to the pistil, have failed to hatch, for one reason or another; or again, that the larva has, for one reason or another, perished. A similar mortality is connected with the similarly difficult and complicated oviposition of the Cynipidæ, as Adler has shown. In dissecting the young fruits of the filamentose Yuccas, with a view to critical examination, I have found that about half of them, on the average, contain nothing; but the proportion varies greatly in different localities and according to circumstances, and I may say that, as a result of my numerous examinations, fully two-thirds of the mature pods are found to contain the larvæ of Pronuba. All the experiments which I have so far made, or have known to be made, prove conclusively that the capsular species never set fruit without her aid.

SELF-FERTILIZATION OF YUCCA.

While the capsular Yuccas are thus sterile wherever Pronuba does not occur, or is excluded from the flowers, there is good evidence that some of the soft-fruited species have exceptionally set fruit where there is every reason to suppose that Pronuba does not exist. I have already shown, in previous writings, how the structure of the flowers of *aloifolia* renders the chance of pollination greater than in the other cultivated forms. There is no style, the stigma is sessile, and the stigmatic liquor is abundant, filling, and even overflowing, the shallow opening or tube. The flowers are always more pendulous, even in full expansion, than in the filamentose species and the stamens relatively longer, (Pl. 35, Fig. 1), so that there is more likelihood of the pollen falling on the papillose apex of the stigma or being brought near it by conniving petals. In this connection I also introduce a figure to show certain variations and deformities which sometimes occur in the pistil of *Y. filamentosa*

(Pl. 38, Fig. 1) and which would suggest another possible method of self-pollination, namely, by the stamens reaching an exceptional length. So far as any proof is concerned, this has never happened with any of the filamentose species, and in any event must be of extremely rare occurrence.

The mere accidental introduction of any of the pollen grains into the stigmatic liquor would in all probability serve to fertilize some of the ovules, though I doubt whether complete fructification could thus ensue. The stigmatic cavity varies very much in the amount of its secretion, which is sometimes abundant and at other times, almost or quite absent, and both Professor Trelease and myself have noticed that it is more abundant on *Yucca angustifolia* in its native habitat than on eastern grown plants.

PRONUBA THE ONLY INSECT POLLINIZER.

In my earlier studies, while the mutually beneficial adaptations of Pronuba and Yucca were at once apparent, I was strongly inclined to believe that there must be, occasionally, accidental pollination of the flowers by other insects, more particularly because of the fact just mentioned that the fleshy-fruited species were reported to occasionally produce seed in regions in which, presumably, the Yucca moth did not exist. I became interested, therefore, in carefully studying the habits of all insects found associated with or found within the flowers of Yucca. I have particularly watched and observed the Pennsylvania Soldier-beetle (*Chauliognathus pennsylvanicus*, Pl. 38, Fig. 3), which is more commonly found within the flowers than any other, and which has a peculiar mouth structure which would lead one to suppose that it would have something to do in attempting to get at the stigmatic liquor. Without going into details, I may say that observations covering a period of nearly twenty years have only served to convince me of the incapacity in this respect of all other insects associated with the plant. The Chauliognathus above mentioned I have never found anywhere near the stigma. All

its movements show that it seeks what little nectar it can find at the base of the flower, which it uses however, chiefly as a place of shelter. It may and I think does feed somewhat on the fallen pollen, and in so far interferes with pollination by the moth. The beetle is almost always found in pairs, the female quite gravid, and while her eggs have not yet been described, and the place of oviposition is yet unknown, they are in all probability laid in the ground, and the larva is known to be predaceous and to be one of the enemies of the common Apple Worm. None of the other insects have ever been observed to go to the stigma and none of them have been observed to gather pollen. The few Hymenoptera, including the common Hive Bee, which are on rare occasions found about the flower, are accidental rather than habitual visitors, and get little satisfaction in the modicum of sweet they can find near the base of the flower. The slightly glutinous nature of the pollen, which is not easily dusted on to hairy insects, makes it extremely doubtful whether it is ever, even by accident, attached to the head of an insect that might by chance seek the stigmatic liquid, and the experiments I have made indicate that, with the long-styled Yuccas, a very thorough and effective insertion of the pollen grains is necessary for fertilization. These general conclusions have been confirmed by specific experiments made for the purpose; for over and over again I have excluded Pronuba by covering the whole panicle with gauze and have admitted all sorts of other insects in the hope of inducing fertilization; but in every case I have failed, whereas, whenever Pronuba has been admitted to the flowers, there has been evidence of her work and fructification.

Pronuba yuccasella is found in all parts of the country east of the Rocky Mountains where the filamentose Yuccas normally range; but has not extended to all sections where they are cultivated. The time of its appearance, as we have seen, is strikingly coetaneous, east of the Missis-

sippi, with the blooming of *filamentosa*; while other cultivated species which bloom either earlier or later, and which, therefore, do not receive the visits of the moth, I have as already stated, never known to bear seed. On the western plains, where *Y. angustifolia* is native, the moth's season of appearance is adapted to the flowering of this particular Yucca. In California, *Yucca whipplei* is pollinized by *Pronuba maculata*, an invariably maculate species; while on the Mojave desert, *Yucca brevifolia* is pollinized by *Pronuba synthetica*, a species still more abnormal than *yuccasella* and modified to fit it to the peculiarities of that peculiar species of Yucca. In the Gulf States the typical *yuccasella* occurs, and fertilizes not only the filamentose Yuccas, but, as already shown, those individuals of the larger, fleshy-fruited species like *aloifolia* which happen to bloom about the same time of the year.

Thus we find that some species of Pronuba is connected with all the Yuccas, so far studied in this connection, and I have no doubt that this will be found to be generally true, so far as the indigenous species are concerned, and that in the native home of any of the species we shall find that pollination depends upon some species of Pronuba. This is rendered certain by the fact that wherever I have been able to examine the mature or partially mature fruit of other Yuccas in herbaria, I have in almost every instance observed the constriction and in most instances seen traces of the puncture and the work of the larva. A large and interesting form of Pronuba may be expected from the Giant Tree Yucca of northeastern Mexico (*Yucca filifera* Chabaud), the *palma* of the Mexicans, with its enormous pendulous panicles from four to six feet long. The fruit is described as often constricted, a result doubtless of the work of Pronuba, and the only pod in the herbarium of the Department of Agriculture, shows this constriction. This baccate fruit is from 2 to 3 inches long and the stigma of the young fruit is farther removed from the anthers than in any other species. The long, thin, smooth and more

flaccid leaves of this tree Yucca permit much more easy study (with the aid of a ladder) of its flowers than of *Yucca brevifolia*, with its stiff, sharp, serrate leaves, which form a veritable *chevaux-de-frise*. The small pod of *Yucca rupicola* from Texas, with its persistent beak-like style, also shows the work of Pronuba and is probably pollinized by a distinct species, as is also, doubtless, *Yucca treculeana*. I shall be delighted to receive any insects found in or connected with the flowers or fruit of any of the different species from Mexico and the south-west, or even ripe fruit, from any one into whose hands this paper may fall, and who has had an opportunity of studying the other species of Yucca which have not yet been studied in connection with pollination.

I have often been struck with the power which the moth has of detecting isolated plants blooming for the first time remote from other plants or in localities where she could not possibly have been previously developed, a fact which indicates that, where abundant, in addition to her ordinary more sedentary duties, she takes long reconnoitering flights.

GENERAL CONSIDERATIONS.

The facts here set forth can be observed by any one who will take the trouble to assiduously investigate them. It has been a source of frequent pleasure to me to introduce my friends to this little moth and its curious ways, and almost every one of my assistants, or those who have been associated with me, have been able to verify the facts repeatedly, while some of them have been of material aid in carrying on the observations; for these observations are more satisfactorily made by two persons than by one, as it is difficult for one person to hold the lantern and at the same time closely investigate. I would here express my particular indebtedness to Messrs. L. O. Howard, E. A. Schwarz, Otto Lugger, Albert Koebele, C. L. Marlatt, and Th. Pergande, who have aided in the different experiments, particularly the latter, who helped me in the earlier ones

in St. Louis and whose interest and enthusiasm have never failed to produce good results in any special work he has done for me.

In this connection I take pleasure in reproducing some experiences of Professor Trelease's, as communicated to me last July, not so much because they so fully confirm my own, as because they are in such refreshing contrast, in their accuracy and insight, to those of some others who have published on the subject. He writes: —

"In addition to my observations noted in Bulletin Torrey Club, 1886, 135, I have watched the moths at work in 1890 and 1891 — the only seasons when I have been at home during the blooming season — and have had my assistants, Duffey and Webber, make independent observations and demonstrate pollination to our garden pupils. The observations were made on *Y. filamentosa*, including its various forms cultivated in St. Louis under other names. Each act of oviposition is so promptly followed by pollination that the moth seems to have it on her mind to perform the latter as a sequel to the former, and I am disposed to think that my belief that either might occur first came from the first observation in a given case happening to begin between the two acts. I have not positively confirmed my observations on the use of the tongue in pollination, though Webber feels certain that he has this year seen it so used. I do not, therefore, look on it as normal — and this would lessen the probability of the habit of thrusting pollen into the stigmatic chamber having been acquired while the moth was feeding on the stigmatic fluid. The latter varies much in quantity, and as you have stated, frequently fills the chamber, especially in the early morning. The septal glands are quite as inactive as I at first stated; but this year we have several times in the early morning found abundant watery fluid both within and outside the perianth, as noted by Meehan, but without ascertaining its source. I am certain, however, from its position, that little if any comes from the glands. Before 9 a. m. we have several times this year seen a few hive bees gathering this fluid, both within the flower and from the outside, and I once saw a bee (Apis) probing, but apparently unsuccessfully and very hastily, the space between the bases of the filaments, and consequently the outlets of the nectar ducts. In addition to my assistants and pupils I have shown the acts of oviposition and pollination to the Vice-President of our Board, to Coulter, Evans and several other visitors to the Garden, as well as to my wife and her sister. Every one who has seen the work done shares your opinion and my own as to the intention shown by the moth. We notice that almost invariably the moth goes down to near the base of the stamens, then creeps up, gets settled between two stamens and backs down a considerable distance while testing the surface of the ovary with the ovipositor

before puncturing it. This year for the first time I have seen Pronuba at the anthers, once with Miss Johnson and Mr. Henry Hitchcock, once with Miss Johnson, and a third time with my wife. None of our observations on this point could be made under a lens, the moth being more shy than at the other work. In the first case a moth that had been seen to oviposit and pollinate once stopped and made a deliberate tour of the nearly empty anthers of the same flower, apparently scraping them out with its tentacles as Boll describes it, and with much the motion seen when she is thrusting pollen into the stigma. Frightened from the first flower, she went to another on the same cluster and rather nervously and hastily explored two anthers, after which, owing to the movements of so many persons about the plant, she became thoroughly alarmed and after nervously running about in several flowers, flew away. In the second case a moth similarly scraped an anther (or coiled and uncoiled its tentacles in it) but was frightened by our motions and, the light being strong (7:15 p. m.), crept to the bottom of the flower, remaining there in the usual diurnal resting position. In the third case my wife saw a moth go through the acts of oviposition and pollination twice, after which she collected pollen from four or five stamens of the same flower; on being called I saw the operation repeated on another stamen. The collection of pollen was not actually seen in either of these cases, but only the perfectly deliberate and intentional act of going to the ends of the filaments and gouging the anthers out with the tentacles, and the observation was not close enough in any case to say that the moth did not meantime bring the pellet together by a lateral motion of the maxillæ and round it in the manner described by you. But the act could have had no other object than the collection of pollen; and the third moth, which was caught, had a fresh ball of pollen.

"Above Manitou, where it is abundant, I studied *Y. angustifolia* in the first ten days of July, this year; — in fact was there for that purpose when your first letter came to St. Louis. Females (weathered) were invariably with pollen. One of them (No. 31) was seen to oviposit and pollinate twice, behaving precisely as in *filamentosa*. I was not fortunate enough to see the collection of the pollen on this plant. The difficulty I have had in watching this part of the work no doubt comes from the fact that the moth can in a few minutes accumulate pollen enough for many pollinations, so that it is a relatively rare operation. My observation on *filamentosa* (assuming her to have had pollen when thrusting the tentacles into the stigma in the first and third cases noted above) shows that she renews this load as it becomes exhausted. Males with very fresh wings were abundant in *angustifolia* flowers, and at the end of the blooming period were much more quiescent than the females, for a male could be found head down after an interval of several hours at night when the flower was re-examined. One pair was seen *in coitu* in a flower. One was seen to be nervously exploring the base of a flower between the filaments, but certainly found little or no nectar, and I have not seen another possible attempt at feeding. In *angustifolia* the stigmatic secretion is more commonly abundant than in *filamentosa*, but there is no greater flow

from the septal glands. Small beetles and flies were very abundant in the flowers and seem to feed on the pollen, collecting on the anthers for that purpose. The former may also gnaw the papillæ of filaments, for the stamens become sodden and wilt within a day or two when these beetles are present — but I have not seen the latter gnawing at them. In their operations upon the anthers these little insects sometimes dislodge a ball of pollen which falls down. In one flower with horizontal pistil such a lump was seen on the green style near its apex; but the probability of any pollen falling in this manner where it could develop its tubes in the stigmatic chamber, is very slight except in case of a possible deformity of the pistil by the reflection of the upper stylar lobe — thus opening the chamber above — or the upbending of the style so that the opening was directed toward the uppermost stamen. Aphides and Coccinellids were of course very abundant, but play no part whatever in pollination. A fair number of capsules were set this year, and all I saw were found to contain larvæ of Pronuba or to show the characteristic scars or constrictions where the moth had pierced the ovary.

"*Prodoxus* was very abundant, and I send you a number of both sexes. Nos. 19, 32 and 33, [all of *Prodoxus decipiens*] were seen ovipositing in stem of *angustifolia*, head upward, the abdomen being worked much as with Pronuba. Numerous Prodoxus were seen flying from flower to flower very actively, and the sexes were seen *in coitu* in a flower, the abdomens working much as in ovipositing. The female in the cases watched by me when ovipositing in the stem, crept *up* a short distance before laying each new egg.

"Apropos of Meehan's idea that the Pronuba moth close-fertilizes the flower, I have seen females when undisturbed go from flower to flower here, and several times in the mountains a female was seen, without having been disturbed, to fly off horizontally from a plant on the steep mountain side, with every evidence of the necessity for a long flight before finding another Yucca."

We have in the structures and functions which are so characteristic of this Yucca Moth, admirable adaptations of means to an end, whether for pollinizing the plant or providing for a future generation. The Pronuba larva rarely destroys more than a dozen of the seeds, so that several may develop within a single pod and yet leave many perfect seeds, while, for the reasons already stated, we occasionally have pods without a trace of the insect.

There is between Pronuba and its food-plant a mutual interdependence which excites our wonder, and is fraught with interesting suggestions to those who are in the habit of reasoning from effect to cause. Whether we believe, as

I certainly do, that this perfect adaptation and adjustment have been brought about by slow degrees through the long course of ages, or whether we believe that they were always so from the beginning, they are equally suggestive. The peculiar structure of the flower which prevents self-fertilization, though on a superficial view it strikes one as a disadvantage, is, in reality, of benefit, as the value of cross-fertilization has been fully established; while the maxillary tentacles of the female moth are very plainly an advantage to her species in the "struggle for life;" and it is quite easy to conceive, on Darwinian grounds, how both these characteristics have been produced in the course of time from archetypal forms which possessed neither, and in reality we get a good insight into the process in studying the characteristics of other species of the family Prodoxidæ. These peculiarities are, moreover, mutually and reciprocally beneficial, so that the plant and the animal are each influenced and modified by the other, and the same laws which produced the beneficial specialization of parts will maintain them by the elimination of all tendencies to depart from them.

The pollen grains would not adhere by chance to the rolled-up tentacles,* and we have seen how full of purpose and deliberation Pronuba's actions are. It may be that all her actions are the result merely of "blind instinct," by which term proud man has been wont to designate the doings of inferior animals; but no one can watch her operations without feeling that there is in all of them as much of purpose as there is in those of the female Pelopæus who so assiduously collects, paralyzes and stores away in her mud-dabs the spiders which are to nourish her young; or in the many other curious provisions which insects make for their progeny, which, in the majority of instances, they are destined never to behold. Nor can I see any good

* I refer here to the filamentose Yuccas. Where they are more distinctly glutinous, as in *Y. whipplei*, the statement is, perhaps, less true.

reason for denying these lowly creatures a degree of consciousness of what they are about, or even of what will result from their labors. They have an object in view, and whether we attribute their performances to instinct or to reason depends altogether on the meaning we give to those words. Define instinct as "congenital habit" or "inherited association" or, as I prefer to characterize it, as *the inevitable outcome of organization*, and most of the doings of the lower animals may justly be called instinctive; but the instinctive and reasoning faculties are both present, in most animals, in varying proportion, the last being called into play more especially by unusual and exceptional circumstances, and the power which guides the female Pronuba in her actions, differs only in degree from that which directs a bird in the building of its nest, or which governs many of the actions of rational men.

THE BOGUS YUCCA MOTH.

The natural history of this species, *Prodoxus decipiens*, has been elsewhere recorded;* but it will be well to show here wherein it differs from the true Yucca moth, notwithstanding the close general appearance of the perfect insects, which resemblance has necessitated the most careful observations and has often neutralized those which were careless. The moths (Pl. 39, Fig. 2, *a*, *b*.), in both sexes, are on the average considerably smaller than Pronuba, and, if anything, more abundant in the earlier opened flowers of *Yucca filamentosa*. The trained observer, however, will have no difficulty in distinguishing them, especially the females, even without close examination of the structure; for he soon comes to recognize the bull-dog like appearance of the head of the female Pronuba, as also the difference in the terminal joints of the abdomen, that of Prodoxus being thicker and darker. The males are distinguished with more difficulty, and yet here the small size

* *Am. Entomologist*, III, p. 142; Proc. Am. Ass. Adv. Sc. XXIX, 1880.

of Prodoxus and the darker coloring of the under surface and tip of abdomen will permit the separation ordinarily, and render more careful examination necessary only in exceptional individuals of both species, *i. e.*, the smaller specimens of Pronuba and larger specimens of Prodoxus. Closely examined, the female Prodoxus is found to have no maxillary tentacles, (there being a mere protuberance instead at the base of each palpus, Pl. 39, Fig. 2, *c.*), and in fact never makes any effort either to gather pollen or work in the stigma. Her ovipositor (Pl. 39, Fig. 3, *b*) while having a similar construction homologically, is yet a very different instrument from that of Pronuba. The male is at once distinguished by his longer and darker, differently shaped genitalia (Pl. 39, Fig. 3, *f*, *g*). This species does not breed in the fruit of the dehiscent Yuccas, but may not infrequently be found in that of some of the non-dehiscent forms, like *aloifolia*. The egg is thrust into the flower stalk, while this is yet sufficiently tender, and oviposition takes place usually before any of the flowers of *Y. filamentosa* are open. The first specimens are found, as a consequence, sometime before the flowering of this species. They are most abundant, however, when this Yucca begins to flower, and then diminish in number, though a few may be found even after the last of the *filamentosa* blossoms have gone. Thus it is always found associated with Pronuba, but in appearance antedates this last and more nearly corresponds with the blooming of *Y. angustifolia*, the stems of which species it most affects, wherever the two are grown together. Prodoxus is, in fact, in large measure dependent upon Pronuba, since, as we have already seen, the flower stems, especially of *Y. filamentosa*, die rapidly when none of the flowers are fructified, and it is doubtful whether Prodoxus could permanently perpetuate itself, except as a dependent on the efforts and effects of Pronuba. This species of Prodoxus is common in the South on *Y. aloifolia*, *Y. rupicola*, *Y. gloriosa*, and *Y. filamentosa*, and in the west on *Y. angustifolia*, and I have rarely broken

open a dry flower-stalk of any species without finding its larva, or examined a green stalk without the evidence of oviposition by the female.

I have often watched the act of oviposition which, though simpler, involves much the same motions as in Pronuba. The female has more difficulty in making an incision, and this is manifest by the many abortive and tentative attempts which she makes in her movements from one part of the stem to another. When she has once succeeded in inserting the ovipositor, and is fairly at work, she becomes as indifferent to examination and interruption as Pronuba, under like circumstances, and has often given me time to make the accompanying sketch (Pl. 39, Fig. 4) in the strong glare of the light. The incision always leaves a slight discoloration in the stem which becomes still more noticeable subsequently and forms a sort of cicatrice. (Pl. 38 Fig. 4, *a a*). The ovipositor—working much as one would work the tip of a hand-saw in making an incision — cuts a channel at a right angle from the surface and about 2mm. deep. The oviduct is short — not long and thread-like as in Pronuba — and the egg (Pl. 39, Fig. 3, *h*) is found at the base of this channel. The plant-tissues surrounding the egg seem to be disorganized by the irritation somewhat as in the case of Pronuba, and it requires nice manipulation to trace the egg which is extremely delicate and easily ruptured and in color and appearance closely resembles the surrounding tissues. It is compressed, elongate and without pedicel. It is, however, plastic and variable in form according to position. The apodal larva is hatched and begins to burrow about the ninth day after the egg is laid and in its curved position and general appearance, looks much more like some Hymenopterous or some Rhynchophorous than a Lepidopterous larva. It is pellucid white in color with black ocelli and brownish mandibles. It molts three times, so far as I have have been able to trace, acquires full growth in about a month and is then more often of a pale emerald-green color. It (Pl. 39, Fig.

1, *a*) possesses no legs whatever, and eats but a small part of the stem (Pl.39, Fig. 1, *f*) preparing in the autumn, for hibernation, a cocoon of white silk which is covered on the outside with its castings and which remains protected within the stem. Before making this cocoon, however, it generally eats a passage-way to the outer covering of the stem and lines this with silk, leaving but a very thin cap (*g*). The chrysalis is formed in the spring, and when about to give forth the moth, pushes its way out through this cap. This happens almost always toward evening and the moth escapes just as the shades of night help to shield it during its more helpless hours, from detection.

Various species of the genus Prodoxus are found associated with the different species of Yucca, breeding either in the flower stems, the main stalk, or sometimes in the fruit, and they will be considered more in detail, in the second part of this article. It suffices here to state that *Prodoxus decipiens* is the only species thus far found east of the Rocky Mountains; that while it is quite constant in coloration east of the Mississippi, it is often more or less spotted with black in Colorado and South Texas, and that it shows the same tendency to retardation in development already noticed in Pronuba, some larvæ remaining in the stems two, three or four years.

Where the stems are allowed to remain on the plant this Prodoxus becomes exceedingly abundant, and the stems are, when one year old, often seen to be riddled with the perforations which the chrysalis made in issuing, and this is especially true of *Y. angustifolia*.

Where the stems are cut, as they ordinarily are, in our gardens, soon after flowering, the larvæ are apt to be destroyed, so that the species becomes scarce.

To recapitulate, the figures on Plate 39, will sufficiently indicate the structural details of *Prodoxus decipiens* and give emphasis to the differences which I have already pointed out between it and *Pronuba yuccasella*, in the larva (Fig. 1 *a*) being apodal (lacking even the thoracic legs

which belong to Pronuba); in the pupa (*e*) among other differences, lacking the series of dorsal spade-like projections; in the form of the claspers in the male moth (Fig. 3, *f*, *g*); in the much stouter and differently shaped ovipositor of the female (Fig. 3, *b*, *d*); and especially in her lacking the maxillary tentacles.

Who, studying these two species in all their characters and bearing, can fail to conclude that, notwithstanding the essential differences that distinguish them not only specifically but generically, they have had a common ancestral origin? Pronuba, depending for existence on the pollination of the flower, is profoundly modified in the female sex in adaptation to the peculiar function of pollination. Prodoxus, dwelling in the flesh of the fruit or in the flower-stem, and only indirectly depending upon the fructification of the plant, is not so modified, but has the ordinary characters of the family in both sexes. In the former, the larva quits the capsules and burrows in the ground; it has legs to aid it in its work, while the chrysalis is likewise beautifully modified to adapt it to prying through the ground and mounting to the surface. The latter, on the contrary — never quitting the stem — has no legs in the larva state, and in the chrysalis state is more particularly adapted, by the prominence of the capital projection, to piercing the slight covering of the stem left ungnawed by the larva. The former is very regular in its appearance as a moth at the time of the flowering of the Yuccas in their native range. The latter appears earlier, as the food of its larva is earlier ready, and the female could not oviposit in the riper stem.

PART II.

This part may be looked upon as supplementary to Part I., and is intended to bring together some descriptive details, as well as some other details upon which the generalizations in Part I. are based. In connection with the new species that will be characterized, it will be convenient, and of some advantage to those interested in the subject, to bring together the previous descriptions.

INTERNAL STRUCTURE OF PRONUBA YUCCASELLA WITH REFERENCE TO THE REPRODUCTIVE ORGANS.

We have already considered the chief external characteristics of the female. If we examine the internal anatomy, we find that the ovaries are large and pyriform, composed of four multilocular tubes gradually enlarging to the point of insertion in the oviducts and with the opposite extremity prolonged into a binding cord attached to the thorax. The oviducts are rather short. There are two large sebaceous glands and two smaller accessory glands, and a large copulatory pouch connected with the oviduct by a short tube or canal which opens close to the entrance of the ductus seminalis, this leading to the receptaculum seminis. This receptaculum is nearly as large as the bursa, pyriform, flattened dorso-ventrally when empty, but more rounded when filled with semen. Its chief characteristic, however, is a pair of curious brown radiate bodies the rays or spicules springing from a central hub, which looks like the disk of a composite flower. These bodies are attached at opposite sides of the pyriform sac and are so large and conspicuous as to be readily seen through the walls of the abdomen when this is mounted in balsam. The hub is concave from the outside and convex from the interior, the disc presenting a granulated structure and the spicules radiating from its margin obliquely into the interior of the sac. Each spicule, when closely examined, is seen to have along its inner border, a hollow groove run-

ning from the base to the extreme tip (Plate 40, Fig. 2, *d*). There are some seventy or more of the longer spicules and other shorter ones; but they vary less in length than in other species. In the impregnated female there is found within this receptaculum and almost filling it, what appears to be an inner sac with a narrow neck entering and following the neck of the receptaculum. This is doubtless but a combined mass of spermatic particles or fasciculi forming what has been called by Lepidopterists the large spermatophore. The albumen-like wall or envelope of this mass is somewhat thickened as it approaches the hubs of the receptaculum but then suddenly becomes thin and is somewhat insecurely fastened to the hubs so that when the spermatophore is detached, there is practically an opening in each side at the point where it was attached to the receptaculum. There are three membranes to this receptaculum, an external or muscular, a middle or serous, and an internal or mucous. The strong fibers of the muscular coat radiate from the border of the hub of one of the chitinous bodies, and are inserted in a similar position upon that of the opposite side. They thus include the whole of the sac until toward the neck, where they change to circular constricting fibers, and thus continue through the duct. Plate 40, Fig. 1, *a* gives an enlarged view of this receptaculum, with a longitudinal section through the hubs at *b*, showing the large spermatophore or inner sac *c*, and the space between it and the walls of the receptaculum, showing the manner in which the hub and the radiate spicules are placed at *d*. In *Pronuba yuccasella* this receptaculum averages about 1.7 mm. in length, by 1. mm. in diameter, the crusher or radiate body measuring 1. mm., the rays averaging 0.43 mm. in length and the hub or axis 0.14 mm. in diameter. By way of exhibiting how very much more strongly developed this receptaculum and its crushers are in *yuccasella* than those in any of the other species, I have introduced (Plate 40, Fig. 2) drawings of the similar organs of

Pronuba synthetica (*a*); *P. maculata* (*b*); and *Prodoxus decipiens* (*c*), drawn to the same scale. In *P. synthetica* the receptaculum averages about 1. mm. in length and 0.66 in width; the crusher has a diameter of 0.43 mm., the longer rays about 0.17 mm. in length and the axis or hub about 0.10 mm. in diameter. The crusher in this species looks much more like a burr, there being 16 of the longer, 24 of a shorter size, 32 yet shorter and a number of the shortest which graduate into the tubercular inner surface of the hub. In *P. maculata* the receptaculum has a length of 0.66 mm., and a diameter of 0.5 mm.; the crusher has a diameter of 0.4 mm., the longest rays a length of about 0.17 mm., and the axis a diameter of 0.06 mm. In *Prodoxus decipiens* the receptaculum has a length of 0.65 mm. and a diameter of 0.3 mm. The crusher measures 0.09 mm. with the longest rays 0.05 in length and axis 0.02 in diameter. The axis is relatively longer than in the other species, and the spicules are much reduced in number.

The object of these chitinous bodies has been somewhat of a puzzle, all the more difficult to solve that they seem to be quite exceptional, and, in the remarkable development which they here present, absolutely unique, so far as I have been able to ascertain. They attracted my attention in my earlier studies of Pronuba and I was glad to find, on visiting Dr. H. A. Hagen in 1880, that he had been very much interested, in his studies of Prodoxus, in the similar but smaller organs of that insect. His explanation of their function, as elaborated in the Zoologischer Anzeiger (Jan. 1882), is doubtless correct, viz., that they serve to liberate the spermatozoa from the spermatophores, but he was in error in locating them in the bursa instead of the receptaculum. The muscular arrangement which I have described is well suited to such a purpose. In the somewhat flattened receptaculum the spicular arms actually intermingle and the radiating muscular coat possesses the only arrangement of fibers which would enable a simple contraction to bring at once the whole contents of the sac into

the nest of pointed blades. At the same time an egress is afforded the liberated spermatozoa through the mouth of the duct — the only point not constricted by the radiating fibers — and once within its walls a successive contraction of its muscular fibers, like the vermicular action in the small intestines of mammals, would cause their ready descent to the oviduct. Thus the spicules not only serve to liberate the spermatozoa, but also to facilitate their egress through the attached base, where the spermatophore wall is thinnest.

THE OVIPOSITOR.

We have already seen, in the characterization of what may be called the external parts of the ovipositor, that it consists apparently of two principal joints, the basal part, when highly magnified, showing an imbricato-granulated surface, the granulations strongest basally, and diminishing distally, and each having a more or less distinctly marked, retrorse point, while the terminal part is smooth and ends in a delicate dorsal, chitinous saw and a strong serrate tip.

It is the working of the ovipositor, however, by the rods connected with it to which I wish to draw more particular attention here. On carefully dissecting the abdomen, there are seen along the dorsal integument four large, distinct, tough, longitudinal muscular bands. Viewing them ventrally each is seen to be inserted upon the widened free end of a slender, brown, horny rod, strongly attached, by an accumulation of muscular tissue, to the base of the vagina. The two inner rods (Pl. 37, Fig. C, *i*, *i*) are nearly parallel, the outer two slightly divergent (*k*, *k*). When the ovipositor is withdrawn the two inner rods extend back beyond the others and reach to the base of the third abdominal joint or even somewhat beyond. These two inner rods converge to form the lateral walls of the ovipositor proper, extending as dark streaks to its extreme tip. The ovipositor is therefore a continuous piece, and in reality not jointed, though appearing so from the different sculpturing of the basal and terminal covering.

This basal and sculptured portion of the integument represents the part which is invaginated when the ovipositor is withdrawn. The outer rods enter on either side of the walls of the anal joint, extending and attached to the tip of the vagina. This arrangement for the exsertion of the ovipositor is at once simple and admirable, the contraction of the muscles forcing out the inner rods and carrying with them the ovipositor, and also extruding the tip of the vagina. The flexible and extensile oviduct is contained within the hollow center of the horny sheath and is doubtless extruded by the contraction of the body walls. In the other two species of Pronuba here dealt with the rods are rather stouter and relatively shorter than in *yuccasella*.

This general internal structure of the female here described is common to all the three species of Pronuba so far known, but the receptaculum seminis and the radiate bodies contained in it are, as already stated, in none of them so large and conspicuous as in *yuccasella*. In *P. synthetica* they are about half as large, with the spicules stouter and straighter and reminding one of some stiff-spined Echinid. In *P. maculata* they are yet smaller. The same general structures also obtain in Proxodus, with much modification of the ovipositor, however, and the radiate bodies of the receptaculum are smaller and seem in some species even to be obsolete. In *P. decipiens* they are smaller in proportion to the size of the sac, which is itself much smaller and more elongate than in *Pronuba yuccasella*. The spicules, however, are relatively larger, though few in number.

THE SPECIES OF PRONUBA.

Generic Characters of Pronuba.

Imago. — *Primaries* (Pl. 34, Fig. 3, *h*) elliptical, the apex subacuminate; disc closed, though somewhat indistinctly between marginal veins 5–8; 12-veined, exclusive of sub-median (1, *a*); costal vein stout, connected with sub-costal near base, and not extending beyond middle of wing; the sub-costal vein sends, from about one-fourth its length from base, a branch which reaches costa where the latter commences to round off; it also sends, from about the middle of the wing, a branch through the discal space, forming an accessory discal cell, and sometimes considerably passing the disc, and forking outside, so as to form marginal veins 7 and 8, though more often forking just at the transverse discal vein; a feeble, disco-longitudinal veinlet starts independently near the base, forks near the middle, and forms a second accessory discal cell; sub-median vein distinct only near the margin, and indicated by an opaque line along the basal half of the fold; internal vein feeble and bifid at basal third. *Secondaries* (Pl. 34, Fig. 3, *i*) broad, subacuminate at tip; shoulder slightly produced and armed in the ♂ with a long spine, and in both sexes with a tuft of long scales; 8-veined, exclusive of sub-median (1, *a*), which is distinct; disc entire; costal vein extending three-fourths of the length of wing; an independent, feeble, disco-longitudinal veinlet, forking about the middle of the wing, the upper branch sometimes considerably passing the disc, and then forking into marginal veins 5 and 6, but more often forking at transverse vein; internal vein feeble and simple. *Head* (Pl. 34, Fig. 3, *a*, ♀), free, sparsely haired; epicranium flattened or depressed; ocelli obsolete; clypeus large; eyes round and salient; antennæ filiform and simple in both sexes, nearly one-half as long as front wing, the basal joint long, bulbous, and twice as stout as the others; maxillary palpi (Fig. 3, *b*) very long, 5-jointed, *the basal joint in the ♀ produced into a long, stout, cylindrical, prehensile tentacle, armed with spines springing from flattened tubercles* (*c*); *this joint in the ♂ a mere blunt-pointed tubercle* (*d*), the other joints almost smooth; 2d, short, stout, and directed backward; 3rd, more slender, and as long again as 2nd; 4th, thrice as long as 3rd; 5th, as long as 2nd, slender and subfusiform; the tip generally notched; labial palpi (*g*) moderately covered with hair-like scales, reaching nearly to base of antennæ; 3-jointed; basal joint curved and stout; 2nd, half as long and straight; 3rd, short and fusiform; tongue long and smooth. *Legs* with the front femora and tibiæ short, the hind femora and tibiæ long and stout; the usual single spur on the front, a pair on the middle, and two pairs on the hind tibiæ. *Abdomen* ♀ with the anal joint long, horny, nearly bare; the ovipositor long, extensile, formed of two rods, the membranous covering of which is imbricato-granulate at base, the tip horny, serrate, and with a serrulate dorsal wing; ♂ shorter, blunt, and slightly swollen at tip; the genital hooks large, sub-spatulate, symmetrical; the upper edge entire and

thickened, the lower edge excavated about the middle, with a tooth or tubercle in middle of excavation.

EGG. — Soft, filiform and clavate.

LARVA. — With thoracic legs but without prolegs.

CHRYSALIS. — With a capital projection and very strong dorsal abdominal spines.

PRONUBA YUCCASELLA Riley.

[Pl. 34, Figs. 1, 2, 3, 4.]

EGG. — Thread-like, averaging 2 mm. in length, with a long pedicel and gradual enlargement toward apex which has a minute indurated tip.

LARVA (Pl. 34, Fig. 1, *a*). — Average length 14 mm. Broadest on thoracic joints, thence gradually decreasing to extremity, which is quite small. Color, carneous, with a paler greenish tint below. No piliferous spots, but a very few minute and short stiff hairs springing from the ordinary positions of such spots. A transverse dorsal wrinkle, on each of the principal joints, more or less distinctly divided in two by a medial-dorsal depression, which is sometimes slightly bluish. Joints deeply incised and with a lateral, sub-stigmatal, longitudinal wrinkle (Fig. 1, *d*). Thoracic legs stout but short, with three joints and a claw. *No prolegs.* Stigmata (9 pair) forming a small rufous circle on anterior portion of joints 1 and 4–11. *Head* (Fig. 1, *e*, *f*, *h*, *i*, *j*, *k*) partially retractile, copal-colored; epistoma sharply defined; labrum slightly pilose; mandibles stout, rounded, and with four acute teeth, each diminishing in size from without; maxillæ with the inner lobe rounded and furnished with (usually two) short fleshy hairs, the palpi four-jointed, the terminal joint with bristles; labium prominent, with the spinneret conspicuous and the palpi two-jointed — the first long, with a fleshy hair at tip, the second small, spherical, and also terminating in a fleshy hair; antennæ two-jointed, the terminal joint with a bristle; ocelli pale, around a dark crescent. Cervical shield flattened and not well-defined.

White when young; more or less green and rosaceous when mature. Mostly curved in the fruit, like the larvæ of the Rhyncophora.

CHRYSALIS ♀, (Pl. 34, Fig. 4, *m*, lateral view). — Average length 8 mm.; greatest diameter about ⅓ the length. Thick and stout, with the dorsum greatly arched. Head with a prominent, conical projection on top and two smaller ones between the eyes. Most characteristic feature a series of six dorsal, arcuated, horny plates — one on the anterior half of each of joints 5-10. These plates have anteriorly 10–12 blunt, flattened, recurved projections, the largest in the middle from which the others are successively lessened. The ends of some of the larger ones are shaped like the share of the more common shovel-plow. In the first row the arcuation is greatest, and the projections largest and directed most forward; all which features are gradually lessened with each succeeding joint. Joint 11 has no plate, and but 4 posteriorly directed spines, while joint 12 has two broad and flattened dorsal processes. Tip of abdomen rounded and reaching beyond the processes. Each joint has a transverse series of stiff yellow hairs, and four such are quite conspicuous on mesothorax, and others on top of the head and on face. Color, when fresh, pale green, with the wing-sheaths darker. When mature, and just before giving forth the moth, the head, thorax, breast between the antennæ, and tip of abdomen, are light brown; the eyes, dorsal plates and projections, darker brown; the wing-sheaths and inter-spaces between dorsal plates, whitish; and the sides greenish.

♂, (Pl. 34, Fig. 4, *l*, dorsal view). — Distinguished generally by the somewhat smaller size; by the dorsal projections not diminishing

on joints 8–11, but rather increasing in size; by the greater shortness of joint 11, and the greater length of joint 12; and by the apex not being so rounded, and not extending beyond the two broad anal processes. At maturity the maxillary pieces are somewhat flatter, owing, doubtless, to the fact that in ♀ the spiny cylindrical tentacles lie stretched nearly their whole length, and cause them to bulge more.

Imago (Pl. 34, Fig. 1, *b*, *c*).—Average expanse, ♀ 25 mm.; ♂ 23 mm. *Primaries*, above, uniformly silvery white, the scales loosely set; fringes concolorous; beneath, pale fuscous, with a brassy reflection; paler internally; fringes either concolorous or paler; costa with a brush of dark hairs. *Secondaries* semi-transparent, pale fuscous both above and below; paler internally, the fringes white and the brush on shoulder dark. *Head* white; antennæ and tongue dingy yellow; maxillary palpi of same color, with the exception of tentacle, which is darker; labial palpi with scales on second joint dark brown above; eyes black. *Thorax* white. *Legs* dingy yellow, more or less covered with pale scales. *Abdomen* with the terminal joint in ♀ always bare, with the exception of a few short, stiff hairs near tip, and the scales on the other joints very loosely attached.

Described from many specimens of both sexes. Remarkably uniform in characteristics, no other variation noticeable than in size.

PRONUBA MACULATA Riley.

[Pl. 42, Fig. 2.]

The species was described (Proc. Am. Ass'n. Adv. Sci., Vol. XXIX., August, 1880), from two females and five males, taken by Mr. H. K. Morrison at Caliente, Kern Co., California, upon the flowers of a species of Yucca, undetermined at that time. Since then I have taken it in the flowers of *Yucca whipplei* near San Diego, Cal., and Mr. A. Koebele has reared it from larvæ in the seed-pods of this same Yucca taken at Newhall, Los Angeles Co., California.

In June, 1876, I received from the late Dr. C. C. Parry pods and flowers of this Yucca collected at San Bernardino, which showed evidence of Pronuba work. The pollen is abundant and quite glutinous, and the tentacles of the moth would seem to be fitted for dipping into and coiling around the same; while the modification of the tongue plainly indicates that it is an accessory organ in this collecting and pollinating, and adds strength to the suggestions already made (p. 110) that the tongue in this genus is not a sucking organ. The stamens in this Yucca are long and straight, the style short and constricted, and the stigma expanded and peltate. Of all the Yuccas it would seem to be most easily self-fer-

tilizable. Yet a Pronuba is needed and it will prove most interesting to observe her manner of working.

Neither pollination nor oviposition has been observed in this species, nor is the chrysalis so far known, and I shall be very glad to get further facts upon the subject from those having opportunity to observe them.

The habits of the larva are very similar to those of *yuccasella*. It leaves the pod as soon as mature, buries in the ground and spins a similar cocoon. I have known a few to remain in gathered pods, however, after having made the perforation which was partly closed with web, and though this would indicate that transformation may exceptionally take place within the pod, the fact has not yet been experimentally proved.

LARVA.—Average length 16 mm. Absolutely identical with that of *yuccasella* both in coloration and structure, the only difference noticeable being that, if anything, it is slightly more slender and with the thoracic segments less swollen.

IMAGO (Pl. 42, Fig. 2).—Expanse, ♀, 19–21.5 mm.; ♂, 17–17.8 mm. *Head* white eyes black, mouth parts yellowish but very sparsely clothed with white scales; antennæ yellowish, the tips fuscous, sparsely clothed with scales on the basal half only; maxillary tentacle (*mt*) yellowish, the base green, large, more swollen, much longer than the tongue, tapering toward tip which is often coiled spirally; hirsute rather than spinose, covered densely with fine hair, intermixed with scales, and a few spines on ventral side; maxillary palpi (*mp*) but half as long as tentacle with the basal or elbowed joint very prominent, the second joint not bulbous and the third joint relatively much shorter than in *yuccasella*; tongue (*t*) short, stout, swollen basally and, together with the maxillary palpi, hirsute (they are smooth in *yuccasella*) the hairs strong and spinous beneath. *Thorax* white; primaries (*pr*) with the upper surface opaque white, bordered with from 10–12 black spots (when all are present) of varying size and running from just beyond the middle of the wing to about the inner angle; the disc with 5 spots, 4 of them in a line from base to apex, the 2nd and 3rd rather farthest apart, the 5th or middle one below and nearest the 3rd from the base; under surface deep fuscous, intensified around the borders and with the spots of upper surface barely indicated; fringes white; secondaries transparent, being very slightly covered with elongate fuscous scales, thickening on the borders, especially toward apex; fringes faintly fuscous; legs white, tarsi very sparsely clothed and yellowish except at extreme tips, which are more fuscous. *Abdomen* white beneath, fuscous above. Integument of head yellowish; of thorax and coxæ black or blackish. Terminal abdominal joint in ♀ short and thick, obliquely truncate from beneath (*a*) usually bare, honey-yellow with its base black; ovipositor stout, decurved, the terminal, horny joint (*tjo*) broad and rounded at the tip and at its edge finely denticulate. Claspers of ♂ short, abruptly curved upward, the base broad and rounded, the tip expanded, leaf-like, twisted, preceded by a deep excavation, but without tooth or tubercle (*gs*, side view; *gp*, posterior view)

Described from 12 ♀♀, 9 ♂♂ from Southern California. In the specimens from Los Angeles Co., California, the spots along the anterior margin are, as a rule, considerably smaller, those at posterior border more or less confluent and often united with the terminal of the discal spots; while two or three of the remaining discal spots are wanting. The apical fringe and a shade of the apex are distinctly dusky or blackish. The secondaries are somewhat darker, especially toward the apex of the anterior margin, with a narrow blackish border all around and more or less distinctly dusky fringe. In specimens not rubbed, the anal joint of the female abdomen, and the male genitalia are freely covered with pale hair.

Examination of the venation in one male shows that marginal veins 7 and 8 arise from the transverse vein independently of the discal branch of the subcostal vein and that the upper fork of the independent discal veinlet is wanting.

In one of the male specimens only four of the spots on the border of the primaries are present, and in this specimen, as well as in one other male and one female, the second discal spot is absent.

PRONUBA SYNTHETICA, n. sp.

[Pl. 41, Figs. 1, 2; Pl. 42, Fig. 1.]

This is the most remarkable of the three known species of the genus and bears a striking general resemblance to certain Saw-flies (genus Dolerus), both in color, habitus, and form. It also strongly recalls, especially in nature and with wings closed, certain Neuropterous species of the family Sialidæ, as *Sialis infumata*.

This general resemblance is due to certain characteristics which are quite abnormal in Lepidoptera, *e. g.*, the naked and fuliginous wings, and the dark, polished and flattened body, with its broadened, horny and angulate tip. But it extends to other details. Thus the two metathoracic pale spots, exactly in the position of the cenci of the Tenthre-

dinidæ, are more noticeable than in any other Lepidopteron, and while careful study shows them to be superficial and hardly homologous with the cenci they would seem to have some similar *raison d'etre.** The broad and deep insertion between thorax and abdomen, with its contrasting coloring, also serves to increase the general likeness.

Though I had briefly visited the tree Yuccas (*Y. brevifolia*) of the Mojave desert, in March, 1887, it was not until April 14th, of the same year, that I was able to spend a whole day among them, mostly in the Antelope Valley. There were but few specimens in bloom, but a number showed the old fruit, and it was with no little satisfaction that in almost every case I found that this indicated the presence of some Pronuba of a relatively large species, as evidenced by the holes of exit of the larva. The flower has the perianth very dense, the petals thick, fleshy, almost leathery, curved in at the tips, the bracts large and tough. Mr. Koebele was with me at the time, also Mr. Frank Godey and Mr. J. G. Wickersham. On account of the scarcity of the flowers, and the difficulty of reaching them without disturbing the moths, but two specimens of this Pronuba were obtained; but the small white *Prodoxus sordidus* was abundant in the flowers and its work everywhere noticeable in the flower-stems. From the fact that I could not be among those curious Yuccas at night, I was unable to witness the acts either of pollination or of oviposition of its particular Pronuba. The structure and characteris-

* The structure and function of these cenci spots in Hymenoptera seem to be little understood. They vary in structure in different families, but for the most part consist of a membrane or lid which covers a cavity and suggests that they are sound-producing organs. In Lepidoptera the similarly placed, but superficial spots, are not specialized, but mere inflations or modifications of the chitine wall. They are wanting in the Rhopalocera and higher groups of Heterocera, while in the Tortricina and Tineina, in which they are usually well developed, they have remained unnoticed because usually hidden by the vestiture, or not conspicuous, through lack of contrasting coloring.

tics of the species are, however, well adapted to the work it has to perform in the densely packed and but partially opened flowers of this Yucca with their denser petals and firmer pistils; for all the parts which are representative of the other species of Pronuba are here more stout, and the denuded and flattened body is well suited to creeping between the flowers. There is no question but that the tree Yuccas represent an ancient type of our flora, and *Pronuba synthetica* may also be looked upon as an ancient type of our Lepidopterous fauna. That it should have so many striking peculiarities that recall insects of other orders, is, therefore, very suggestive. I was very anxious to obtain the larva and chrysalis of this species, and the following year Mr. Koebele, at my request, revisited the tree Yuccas and succeeded in May, 1888, in obtaining infested fruit. As soon as this was received, the larvæ left the pods and entered the ground, some of them forming cocoons almost identical in appearance with that of *yuccasella*. Others remained in the larva state, without forming cocoons. Indeed, one peculiarity noticeable was the great length of the larval life, as a few had not yet formed their cocoons by the end of 1889, or more than a year from the time they were received, while one was living and unchanged, in its cocoon, in August, 1891, or nearly two years and a half from the time it left the fruit. However, most of those that were reared to the imago state, whether by Mr. Koebele in California or at Washington, issued the following March or April. These facts would indicate that while normally the moth is produced the ensuing year, yet belated individuals may not issue from the ground until the second or even the third year, and I have been informed that it is not an uncommon thing for *Yucca brevifolia* to produce no flowers over large districts during some years. The tendency to retardation in development is, under these circumstances, advantageous to the species.

LARVA (Pl. 41, Fig. 2, *a*). — Length when full-grown, 14 mm. Somewhat more cylindrical than that of *yuccasella*, the general color being bluish-green tinted with a rosaceous hue; otherwise undistinguishable from those of the other two species.

CHRYSALIS (Pl. 41, Fig. 2, *b*, *c*). — In size, general shape and arrangement of the spines similar to that of *yuccasella*. but readily distinguished by the wing-sheaths in both sexes reaching only to the sixth abdominal joint and the posterior legs to the seventh, whereas in *yuccasella* the former reach to the eighth and the latter to about the middle of the ninth. The medio-dorsal spines are also longer, more prong-like and less spatulate, while the capitate spine is perhaps less prominent. The difference is more particularly noticeable in the greater length and prominence of the two spines on the second abdominal joint. The anal joint in the male is narrower and comparatively longer, and the two terminal teeth much shorter than in the female, also not so well defined as in *yuccasella*. The anal segment in the female is broader and stouter than in *yuccasella*, with the teeth shorter, stouter and further apart. (*c*, *d*, *e*, *f*, *g*, *h*.)

IMAGO (Pl. 41, Fig. 1, *a*). — Expanse ♀, 15-20 mm.; ♂ 16-18 mm. Body flattened, piceous. Wings smoky-gray; the scales sparse and as easily lost on the upper surface, especially of primaries, as in the Sesiidae, so that none but those carefully killed soon after issuing from the chrysalis show the wings well covered. In such specimens the general color is cinereous, the primaries but slightly darker than secondaries, the scales being narrow and elongate, mostly gray, but with an admixture of black ones. The exposed membrane of the wing is fuliginous except a narrow discal space and more or less of the costal region which remain sordid white. Fringes paler but sparse and easily lost except at anal angle of hind wings, where they persist. Veins black and strong. Body but sparsely clothed in freshest specimens and soon becoming bare except at neck; highly polished and minutely punctate, and in some specimens with metallic tendency. *Head* (Fig. 1, *b*) with the hair pale ferruginous; eyes brown, naked; labial palpi brownish-black with sparse white scales; maxillary tentacles stout and brown, shorter than tongue; max. palpi nearly as long as tentacle, basal joint stout, rounded, joints 2 and 3 short, sub-equal in length, joint 4 very long, terminal joint with two spines at tip; tongue very stout, long and ferruginous; antennae black. *Thorax* with two singular transverse-ovoid translucent and somewhat opalescent spots recalling the so-called cenchri of Tenthredinids; legs stout and dark, the hind tibiae and tarsi pale ferruginous. *Abdomen* separated from thorax dorsally by a broad and deep suture which is pale rufous by contrast with the general piceous color; anal joint (Pl. 42, Fig. 1, *c*, *d*) in ♀ rufous, with darker shade at base, the sides compressed from above and expanded into a broad and angulate wing, the borders of which are thickened and stiffened and converge to a rather sharp tip which is, however, obliquely truncate from the side; ovipositor issuing generally at right angles and with the same parts as in *yuccasella* but all stouter and shorter (*e*, *f*). In the ♂ the dorsal fulvous suture or pit between thorax and abdomen is more profound and concave, the abdomen is less flattened and the claspers are brown, very stout, one-half as long as the abdomen, the basal part broad and leaf-like, the terminal part abruptly curved upward, dilated into a decurved triangular tip, and the prong quite long, slightly curved and denticulate at tip (*a*, *b*).

Described from 28 ♀♀, 10 ♂♂, from the fruit of *Yucca brevifolia*.

THE SPECIES OF PRODOXUS.

It is my design to give here descriptions of all the species so far as known. The early stages of these different species are remarkably similar and it is extremely difficult — at times quite impossible — to point out characters by which to separate them. It will be well, therefore, first of all to reproduce the original description of *Prodoxus decipiens*, somewhat amplified, and merely describe the others by comparison. The ovipositor varies in appearance according as it is extruded or not.

Generic Characters of Prodoxus.

Imago.—Agreeing with Pronuba, except in the following important particulars: The basal joint of the maxillary palpi in the female is not produced into a spinous tentacle, but is formed just as in the male, being a mere blunt-pointed tubercle.

Larva. — Apodous.

Chrysalis. — Without prominent dorsal spines.

PRODOXUS DECIPIENS Riley,

[Pl. 39, Figs. 1, 2, 3, 4.]

Egg.—Soft, white, easily yielding to pressure, and hence variable in shape, but usually elongate, rounded at both ends about 0.4 mm. in length, and less than 0.1 mm. wide.

Larva (Pl. 39, Fig. 1, *a*). — Length 5 to 7 mm. Apodous, plump, broadest on joints 2 and 3, tapering thence posteriorly, with the dorsum strongly arched and the head and prothoracic joint more or less fully bent down on the breast. The body is glabrous and not conspicuously wrinkled and the general aspect strongly recalls some Hymenopterous or Rhyncophorous larvæ. Head small, retractile. Stigmata placed as in Pronuba, *i. e.*, the first pair on the hind portion of the prothorax and rather lower down than the succeeding 8 pairs, which are on the anterior portion of joints 4 to 11, the prothoracic spiracles somewhat larger than the rest. Color of body either pale yellowish-white, or emerald-green, this last being the more usual color of the mature and especially of the hibernating specimens. The head is honey-yellow with a dusky spot on each side, a dash on each suture of the epistoma, the mouth dark brown, the mandibles black, labium and maxillæ white; the mandibles have four teeth, much blunter than in Pronuba, though the labial palpi are smaller and more plump and the labium and maxillae do not surpass the mandibles. The cervical shield is not defined as in Pronuba, but consists of 4 chitinous patches of the same color as the head.

Chrysalis (Pl. 39, Fig. 1, *e*). — Average length about 6 mm. Of the same color as in Pronuba but much more slender, with the dorsum less arched and lacking the characteristic dorsal, arcuated plates with their peculiar recurved, flattened spines, there being in place of them the barest indication of a transverse row of minute points or teeth not re-

curved but pointing posteriorly, near the anterior border of joints 6-11; joint 5, which is so strongly armed in Pronuba, being here perfectly smooth. Joint 12 in both sexes is unarmed as in ♂ but not in the ♀ Pronuba, while the terminal subjoint is much swollen and curved upward, with two minute spines taking the place of the broader, compressed processes in Pronuba. The capitate point is much stouter and beak-like, flattened and somewhat excavated laterally, so that the upper edges form each a sharp carina. The sexes are only distinguishable by the somewhat less swoolen sub-joint in the ♀ and her longer leg-sheaths, which reach a little beyond the tip of the body, whereas in the ♂ they fall short of the tip.

Imago ♀, (Fig. 2). Average expanse 16 mm. In general appearance closely resembling *Pronuba yuccasella*, but the upper surface is ordinarily more silvery and less creamy in appearance, and the dark shades, as of the eyes and the dark hairs of the palpi, front legs and tarsi and at the base of the costa on primaries, are more pronounced and blackish. The under surface is somewhat darker, and the tip of the abdomen not truncate but pointed, and slightly beveled off superiorly. The terminal joint is swollen and darker than in Pronuba. The ovipositor is stout, dark brown, laterally flattened, between three and four times as broad as in Pronuba, shorter, the sculpture of basal portion closer, finer and ribbed, the tip obliquely cut off below and having a series of minute teeth, the ventral one being more conspicuously produced, and a series of eight or nine more prominent teeth along dorsal edge, while two distinct grooves run along the whole length and several smaller ones are noticeable near the tip. (Fig. 3, *a*, *d*.)

♂, Somewhat smaller than ♀, the genitalia being more elongate and prominent than in Pronuba, the claspers extending fully twice as far, less recurved, and having on the lower border 4 small black points or tubercles, equidistant from each other. (Fig. 3, *f*, *g*.)

Described from numerous specimens of both sexes, either found in the flowers or reared from the stems of different species of Yucca throughout the eastern States.

All the specimens obtained or reared east of the Mississippi have been immaculate, with the faintest tendency to a few minute spots; but western forms, especially those from Texas and Colorado, show a greater tendency to maculation, the number of spots ranging from 1 to 5 or more, usually arranged along the middle in the form of a broad W, a dot representing each angle and each outer tip. When the basal spot alone is absent the four remaining present the figure of a rhomboid. When it is absent and there is another spot posteriorly we have the W inverted. When a single spot is present there is no regularity in its position, and it may be differently placed on the two opposite wings of the same specimen. There may also be more spots on one wing than on the opposite one, while I have seen specimens with the thorax spotted with two metathoracic mesial

spots, one above the other. When there are more than five spots, the additional spots are ranged around the posterior border. These spots are sometimes so small as to be confined to a single scale.

PRODOXUS MARGINATUS Riley.

[Pl. 43, Fig. 2.]

This species was described in 1880 (Proc. A. A. A. S. Vol. XXIX.) from specimens collected by Mr. H. K. Morrison in Kern Co., Calif. I have since been able, through Mr. Koebele's collecting in 1886, to rear it from the petioles and basal portions of the pods of *Yucca whipplei* obtained in Los Angeles Co., Calif., in the flowers of which it is also frequently met with from the end of April to the end of June. Its habits, so far as they have been observed, are quite similar to those of *decipiens*, the larvæ remaining within the petioles nearly a year, transforming and issuing during the ensuing month of April. No especial observations have been made on the method of oviposition and the egg has not yet been obtained.

LARVA. — Average length 3–4 mm. General color pale bluish-green. Head honey-yellow, marked each side of the clypeus with some more or less distinct but irregular dusky patches. The cervical plate concolorous with the body, but marked in front and behind with two faintly dusky patches, otherwise agreeing precisely with *P. decipiens*.

CHRYSALIS. — Except in the smaller size and less prominent spines and sculpturing, agreeing exactly with that of *decipiens*. This is especially true of the male chrysalis. The frontal tubercle in the female, besides being smaller, lacks the sharp lateral carinæ and has on the sides a shallow longitudinal channel or depression. The dorsal tubercles on the eighth abdominal joint are also transversely ovoid instead of being perfectly cylindrical at the base.

IMAGO (Pl. 43, Fig. 2).—Expanse 8-10 mm. Color white, the clothing of body very sparse, especially on the abdomen, and showing more or less distinctly the integument which is dark brown often with an æneous tinge. Antennæ bare towards tip and yellowish. Primaries (Fig. 2, *pr*) satiny-white with a terminal black band of varying width; under surface fuscous, almost black on costal and posterior borders; fringes white. Secondaries white with a broad costal and apical fuscous shade; under surface concolorous; fringes white. Apical abdominal joint of ♀ blackish, slender, very obliquely truncate above, the tip blunt-pointed (Fig. 2, *a*). Ovipositor short and stout; the horny terminal joint gradually narrowed to the pointed tip, the upper edge very finely and acutely serrulate (Fig. 2, *tjo*). Claspers of ♂ (Fig. 2, *c*) not dentate, their form much concealed by scales, the large arms broad and of nearly uniform width; large upper basal piece obtusely angulated in the middle.

Described from 21 ♀ ♀ and 22 ♂ ♂ collected and reared in Southern California.

The males are as a rule smaller than the females with the marginal band often much narrower, sometimes reduced to a small dot or even entirely wanting.

PRODOXUS INTERMEDIUS Riley.

[Pl. 43, Fig. 1.]

This species was described in the same paper as the preceding from two female specimens taken by Mr. J. Boll in Texas and one taken by myself July 18th, 1887, at Ute Pass, Colo. No others have been taken since, and the early states and the male remain unknown. This species is very interesting as showing how closely, except in lacking the characteristic maxillary tentacle, the species of Prodoxus may come to the typical Pronuba. The character of the ovipositor in this Prodoxus would indicate that the species breeds perhaps normally in the fruit, notwithstanding it can have nothing to do with pollination. It would thus be entirely dependent for its existence on the efforts of Pronuba.

IMAGO (Pl. 43, Fig. 1), ♀.— Expanse 28.5 mm. Coloration as in *Pronuba yuccasella*. Basal joint of the maxillary palpi not provided with a tentacle, but having a slight tubercle at the tip. Apical joint of the abdomen (Fig. 1, *a*) shaped as in *Pronuba yuccasella*, but slightly deeper and possibly a little thicker. Ovipositor, shaped as in *Pronuba yuccasella*, but slightly stouter, more acuminate at tip and with the serrations of membrane finer and more numerous (*tjo*). The sculpture of basal joint shows like very fine punctations in angular rows (*bjo*).

Described from 2 ♀ ♀ from Texas and 1 ♀ from Ute Pass, Col., July 18, 1887.

PRODOXUS CINEREUS Riley.

[Pl. 43, Fig. 4.]

Originally described in the same paper as the preceding from seven males collected in Kern Co., California, by Mr. Morrison. Since that time I have obtained numerous specimens either from the flowers of *Yucca whipplei*, in Los Angeles Co., California, collected by Mr. Koebele, or reared from the flower stems of the same species of Yucca.

The species prefers the main stem of the plant for purposes of oviposition. Stems, received in May, 1887, gave forth the moth during the latter part of that month, but others issued from the same stems during the same month of May in the consecutive years of 1888, 1889 and 1890, thus indicating great variation in the development of the species and a remarkable tendency to retarded development. The eggs and the early states have not been observed, nor the earlier states preserved and described.

IMAGO ♂. — Expanse 12 mm. Head, thorax, legs and apical ventral joints whitish. Primaries ashy; secondaries and under surface of all the wings brown with a cinereous reflection. Tip of maxillary palpi and apical third of antennæ black; the integument of body black. Claspers (Fig. 4, *a*, *b*) dark testaceous, similar in form to those of *decipiens* but without teeth; large upper basal piece broadly rounded or subtruncate; the smaller piece beneath it of similar shape.

♀ showing no differences whether as to size or coloration of scales, the head being somewhat darker, on the average. Anal joint of same form as in *decipiens*, the ovipositor being more slender than in any of the other species of the genus and coarsely toothed along the entire upper edge.

Described from many specimens.

PRODOXUS ÆNESCENS Riley.

[Pl. 43, Fig. 3.]

This species was also described in the same paper as the preceding from 3 females and 8 males collected by Mr. Morrison, in Kern county, California, but I have since reared it from the main stems of *Yucca whipplei*, also collected by Mr. Koebele, at Newhall, Los Angeles Co., California. The egg and mode of oviposition have not yet been observed, but Mr. Koebele reports that the larger larvæ (doubtless those which produce females) work in the stem with the head upward, while the smaller larvæ work downward, and that they go through their transformations in the month of May. I have serious doubts whether there is any sexual difference in the position of the larvæ in the stem, as might be gathered from his observation.

LARVA. — Attaining a length of 9 mm. with a diameter of only about $\frac{1}{8}$ the length, and distinguished from the other species by this greater slenderness and relatively greater length. The body tapers but little posteriorly and the general aspect is more that of a Cerambycid larva

than of a Rhyncophorous larva. General color pale greenish. Head honey-yellow, darkest in front with a broad brownish anterior border, more or less distinct, and a narrow blackish lateral line and dusky markings each side of the clypeus, thus resembling that of *P. marginatus*. The cervical shield with two or three more or less confluent faintly dusky spots anteriorly and 2 rather well defined somewhat quadrate black spots posteriorly.

CHRYSALIS. — Scarcely distinguishable from that of *decipiens*, except by the smaller size, smaller spines, and finer sculpturing. The frontal tubercle is relatively shorter and stouter.

IMAGO. — Expanse, ♀ 14.7 mm.; ♂ 11.2—14 mm. General color, bronzy, the primaries with a distinct purple reflection. Under surface of thorax, the coxæ and the femora clothed with white scales. Head whitish, with scattered black hairs; labial palpi with black hairs; 4th and 5th joints of maxillary palpi and the antennæ, except at the base, black. Integument black. Apical abdominal joint (Fig. 3, *a*) swollen as in *P. decipiens* and obliquely truncate from above, but the tip is also truncate from beneath and the lower border is slightly excavated. Ovipositor short and stout, very broad; the upper border of the horny terminal joint (Fig. 3, *tjo*) thin, arched and finely serrate, the tip obliquely truncate beneath and at the base of the truncation forming a small, thin tooth, the base beneath forming a blunt tooth, the border between these teeth retuse. Claspers of ♂ (Fig. 3, *c*) with no teeth on the arms beneath; the arms more slender than in *cinereus* and narrowed more abruptly near the base; the broad basal part with a small tooth at the apex within. Large upper basal piece forming a stout process at the apex.

Described from 20 females and 38 males taken from Southern California, many of them reared from the main stem of *Yucca whipplei*.

PRODOXUS PULVERULENTUS, n. sp.

I have five specimens of this species, all females, two of them reared from the seed-pods of *Yucca whipplei* in May, 1886, by Mr. Koebele, the pods obtained at Santiago, California, while three specimens were given me by President H. W. Harkness, and Mary K. Curran, of the California Academy of Science, in April, 1887, and obtained from the flowers of the same Yucca. The adolescent states are still unknown.

IMAGO ♀. — Expanse 9–10 mm. General color, white; head with the antennæ white, the basal half fuscous; eyes brown; palpi pale yellowish, hairs white. *Thorax*, with the hair mixed with a few blackish scales; primaries white, more or less densely sprinkled with blackish scales at the posterior third and sparsely so on the remaining portion. These dark scales produce a powdery appearance of the wings, the amount varying in the specimens before me, there being in two of them but a faint trace of the darker scales; secondaries white, with a broad dusky anterior margin; under surfaces more densely flecked with blackish scales and hence somewhat darker. *Abdomen* fuscous above, with a few long whitish hairs on the terminal two joints; venter and legs white. Tip of the abdomen shaped as in *P. marginatus*.

PRODOXUS Y-INVERSUS, n. sp.

[Pl. 43, Fig. 5.]

Specimens of both sexes of this species were reared from parts of a pod of an unknown species of Yucca (but doubtless *Y. baccata*) received from Mr. D. C. Chapman, of Washington, D. C., who had obtained them in May, 1883, from New Mexico, the moths issuing during May of the following year. The larvæ infest the fleshy portions of the pod and produce hard, gall-like swellings. The cocoon, which, as with the other species, is constructed within the burrow, is pale brownish, and resembles an elongate, cylindrical bag, rounded at the base and cylindrical at the apex. When ready to transform, the larva retires to the lower third of the bag and separates it from the upper two-thirds by a dense, tough, delicate whitish layer of silk, thus dividing the cocoon into two unequal chambers. No larvæ were preserved, but those which were noticed in cutting open the swellings showed a remarkable resemblance to those of *decipiens*. The chrysalis also has not been studied.

IMAGO.— ♀. Average expanse 14 mm. ♂ 10–12 mm. General color white. Head, thorax, legs and abdomen white beneath, the hairs between the antennæ occasionally yellowish. Eyes black; palpi white; tip of labials yellowish; tongue pale yellowish. Primaries (Fig. 5, *a*) marked with black as follows — a costal streak along the basal half, widening posteriorly and more or less completely fused with a round spot near its end. An elliptical or roundish spot about the middle of the wing at the basal third; a more or less sharply defined inverted-Y-shaped band across the posterior third of the wing, with its exterior arm generally connected posteriorly with a black patch which extends along the posterior border but is more or less broken at the extreme border and also along its inner margin. This terminal dark patch usually broadens toward the apex and is sharply cut off on the costa at about the outer fourth of the wing. Secondaries pale yellowish, darkest at apex; fringes concolorous. Undersurfaces with the dark markings of the primaries less sharply defined. Abdomen, brownish above, the male claspers (Fig. 5, *b*, *c*), yellowish-brown, almost bare, quite slender, and gradually narrowing toward the tip, which is almost acute; each arm is provided with 5 or 6 very small, cylindrical, acute teeth at the posterior edge; basal lobes are almost circular and concave at the inner side; upper basal plate triangular. Anal segment of the female obliquely truncate from above, but slightly so beneath, the ovipositor stout, yellowish-brown, its terminal part slender, compressed laterally, the upper edge of the apex being finely and acutely serrate. (Fig. 5, *d*, *e*.)

Described from four males and seven females, no two of which are exactly alike in the marginal details of the inverse Y-shaped band, nor in those of the terminal patch.

PRODOXUS RETICULATUS, n. sp.

[Pl. 43, Fig. 7.]

I have but three females of this species, taken by Mr. Koebele in March at Los Angeles, California, but without any notes of habit.

IMAGO.— ♀. Expanse 10–11 mm. General color, white. Body with whitish hairs, those of the head inclining to yellowish, intermixed with a few darker hairs, especially around the antennæ; the terminal joint of the palpi pale fuscous; vestiture of the legs superiorly dusky, with a slight cupreous reflection. Primaries with transverse blackish bands as follows: An oblique basal band much constricted at middle so that costal half is usually triangular; a narrow band along the posterior border and the intervening space between these two bands occupied by a broad W-shaped band, the outer arms of the letter running parallel with the basal and terminal bands. Fringes white. Secondaries gray; fringes somewhat darker. Undersurfaces gray, with a brassy reflection, the darker markings of the primaries being but faintly indicated. *Abdomen* with the anal joint perpendicularly truncate, the flexible basal part of the ovipositor rather broad at base and pale, while the terminal part is stout, sharp and brownish in color.

PRODOXUS COLORADENSIS, n. sp.

[Pl. 43, Fig. 6.]

Of this species I have seen but a single male, taken in 1884, by Mr. Morrison, in Colorado. In general appearance, as well as in the genital characters, it seems to be quite closely related to *P. y-inversus*.

IMAGO.— ♂. Expanse 11 mm. General color white and somewhat glossy, the hair of the head being faintly yellowish between the antennæ. Eyes black; antennæ white at basal third, the rest fuscous; palpi and tongue pale yellow. A few hairs on the maxillary palpi and the extreme tip blackish. Primaries (Fig. 6, *a*) with a well defined band starting at right angles from costa to basal third and then obliquing suddenly though slightly toward base; a somewhat similar band across the middle of the wing obliquing first in the opposite direction, *i. e.* posteriorly, and then almost parallel with the first band; and a forked or somewhat Y-shaped band across the posterior third of wing; a terminal black border connects with this Y-mark at anal angle but not at apex, and there is more or less black at base of wing. Secondaries whitish above; fringes white. Undersurfaces faintly dusky with a slight æneous reflection and the markings of the primaries less defined than above, and the secondaries somewhat dusky toward the apex. Abdomen brownish with the scales also brownish, especially along the sides, but white beneath. Claspers pale brown, covered with long yellowish hairs and almost identical in form with those of *y-inversus* (Fig. 6, *b*, *c*).

PRODOXUS SORDIDUS, n. sp.

I first found this species in the flowers of *Yucca brevifolia* on the occasion of the discovery of *Pronuba synthetica*, while other specimens were subsequently obtained by Mr. Koebele. In general appearance the species seems nearest related to *P. cinereus*, being, however, much paler, with the greater portion of the hind wings white.

IMAGO. — ♂. Expanse 8–10 mm.; ♀ 11–13 mm. General color creamy-yellow, the females showing the most white. A more or less distinct dusky or blackish posterior margin to the secondaries, the dark color broadening toward the apex. The undersurfaces have a tendency to metallic reflection and the darker color of the hind border of the secondaries is repeated. Abdomen grayish-brown dorsally, with iridescent reflection. Anal segment of ♀ reddish-brown, obliquely truncate from above, the tip rounded. Ovipositor yellowish-brown, slender and finely denticulate along the upper edge. Male claspers similar in shape to those of *decipiens* but more slender, the base comparatively broader and the apex more abruptly rounded; the basal side-piece narrower and pointed at tip; the posterior edge with from 3 to 5 small slender teeth.

Described from 5 males and 5 females.

EXPLANATION OF PLATES ILLUSTRATING YUCCA MOTH AND YUCCA POLLINATION.*

PLATE 34.

Fig. 1.— *Pronuba yuccasella:* *a*, larva; *b*, ♀ moth with closed wings; *c*, do. with wings expanded — nat. size; *d*, side view of one of the middle joints of larva; *e*, head of larva, beneath; *f*, do., above; *g*, thoracic leg of same; *h*, maxilla; *i*, mandible; *j*, spinneret and labial palpi; *k*, antenna — enlarged.

Fig. 2.— *Pronuba yuccasella:* moth soon after issuing from chrysalis, showing position of wings when expanding and before fully dried. ×3.

Fig. 3.— *Pronuba yuccasella:* generic characters — *a*, side view of head and neck of female denuded, showing how the collected load of pollen (1) is held by the tentacles (2); (3, 4, 5, tongue, antenna and maxillary palpi;) *b*, maxillary tentacle and palpus; *c*, an enlarged spine; *d*, maxillary palpus of ♂; *e*, scale from front wing; *f*, front leg; *g*, labial palpus; *h*, *i*, front and hind wings denuded; *j*, anal joint of female with ovipositor partly extruded showing silk-like oviduct — all enlarged.

Fig. 4.— *Pronuba yuccasella:* *l*, male chrysalis; *m*, female do.

Fig. 5.— Mature pods of *Yucca angustifolia:* *a*, artificially pollinized and protected from Pronuba; *b*, normal pod, showing constrictions resulting from Pronuba puncture and exit holes of larva; *c*, one of the lobes cut open showing larva within.

PLATE 35.

Fig. 1.— Flower of *Yucca aloifolia* showing stouter pistil and shorter style as compared with *filamentosa*.

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* The author is under obligations to Prof. Edwin Willets, Assistant Secretary of Agriculture, for the use of the illustrations Pl. 36, Figs. 1, 2; Pl. 37, Fig. 2; Pl. 38, Fig. 2, and Pl. 41, Figs. 1, 2. The others are either from his drawings and previously used, or made from his studies especially for this article, by Miss Lillie Sullivan.

Fig. 2.—*a*, longitudinal section of pistil of *Yucca filamentosa* showing (*b*, *b*) punctures of Pronuba, and (*c*, *c*) the normal position of her eggs in the ovarian cell—×11; *d*, section of a punctured carpel 7 days after oviposition showing the egg yet unhatched and the manner in which the ovules in the neighborhood of puncture have been arrested in development so as to cause the constriction—×2; *e*, section of an older carpel showing the larva above the original puncture—×2; *f*, a seed 13 days from oviposition showing young larva at funicular base—×8.

PLATE 36.

Fig. 1.—Transverse section of one of the carpels of pistil, after the flower has opened: *a*, ovule; *b*, funiculus; *c*, placenta; *d*, ovarian cell; *e*, fibro-vascular bundles; *f*, fibro-vascular tissue; *g*, primary dissepiment.

Fig. 2.—Transverse section of pistil about middle, one day after oviposition, showing (*a*, *a*) puncture of ovipositor, and (*b*, *b*) position of egg—×17.

PLATE 37.

Fig. 1.—A, tip of anal joint and vaginal projection of ♀ *Pronuba yuccasella* from side showing ovipositor with parts extended: *b*, basal part; *c*, its file-like surface; *d*, terminal part with its dorsal serrate wing (*f*), its dentate tip (*e*), its ventral membranous outlet (*g*) and the extended oviduct (*h*); B, the same parts further enlarged; C, ventral view of tip of abdomen showing the two pair of rods *i*, *i* and *k*, *k* with their muscular attachments, the parts of ovipositor similarly lettered as in A; *m*, *m*, eggs taken from Yucca pistil; *n*, egg showing development of embryo; *o*, mature egg from ovary of ♀; *r*, *s*, genital claspers of ♂, lateral and dorsal views—all enlarged, the pedicels of eggs not sufficiently slender.

Fig. 2.—Flower of Yucca with near petals removed to show normal position of Pronuba in ovipositing.

PLATE 38.

Fig. 1. — Pistils of *Yucca filamentosa*, showing (*a*) a deformed specimen and (*b*, *c*, *d*) varying lengths of the stamens.

Fig. 2. — *Pronuba yuccasella*, female, in the act of gathering pollen from the anthers — ×5.

Fig. 3. — *Chauliognathus pennsylvanicus: a*, larva; *b*, its head and prothorax; *c*, *d*, *f*, *g*, *h*, its mouth parts; *e*, its leg; *i*, beetle — all enlarged but *a* and *i*.

Fig. 4. — Flower-stem of Yucca showing scars resulting from oviposition of female *Prodoxus decipiens* (*a*, *a*) and pupal exuvia of same protruding (*b*, *b*, *b*).

PLATE 39.

Fig. 1. — *Prodoxus decipiens: a*, larva; *b*, head from above; *c*, *d*, left jaw and antenna; *e*, pupa; *f*, infested stem cut to show the burrows, castings, cocoons (*i*), exit hole (*g*) and pupa shell (*h*) — all enlarged but *f*, the hair line between *a* and *e* showing natural length.

Fig. 2. — *Prodoxus decipiens: a*, imago, wings closed; *b*, female do. wings expanded — nat. size; *c*, maxillary palpus with its basal tubercle enlarged.

Fig. 3. — Genital characters of *Prodoxus decipiens*: *a*, tip of ♀ abdomen rendered somewhat transparent; *b*, basal part of ovipositor; *c*, its sculpture; *d*, terminal part of same; *e*, its tip more enlarged; *f*, genitalia of ♂ from side; *g*, do. from above; *h*, egg — all enlarged.

Fig. 4. — *Prodoxus decipiens:* Female in the act of ovipositing — ×3.

PLATE 40.

Fig. 1. — *a*, receptaculum seminis of *Pronuba yuccasella*, showing radiate bodies or crushers and muscular structure; *b*, same, longitudinal section through axle of hub, showing the main sac and the inner sac at *c* and the radiate bodies in the intervening space at *d* — ×40.

Fig. 2. — *a*, outline of receptaculum seminis of *Pronuba synthetica*; *b*, do. of *Pronuba maculata*; *c*, do. of *Prodoxus decipiens*, all drawn to same scale as figure 1; *d*, enlarged spicule showing ventral groove and a transverse section of same.

PLATE 41.

Fig. 1. — *Pronuba synthetica: a*, ♀ with wings expanded, hair-line showing natural size; *b*, lateral view of the head and neck, more enlarged, showing a purely lateral view of the trophi, not in pairs to avoid confusion. The maxillary palpus (*mp*) with its tentacle (*mt*); tongue (*t*); labial palpus (*lp*); base of antenna (*at*); eye (*e*); front trochanter (*ft*).

Fig. 2. — *Pronuba synthetica*: *a*, larva, from side; *b*, ♀ chrysalis, ventral view; *c*, do., lateral view — nat. size in hair-line; *d*, lateral; *e*, dorsal view of anal joints of ♂; *f*, *g*, do. of ♀; *h*, dorsal view of 2nd and 3rd joints of abdomen — all more enlarged.

PLATE 42.

Fig. 1. — *Pronuba synthetica: a*, enlarged view genitalia of ♂ from side; *b*, do., from behind; *c*, anal joint of female with ovipositor exserted, dorsal view; *d*, do., lateral view; *e*, ovipositor, dorsal view, still more enlarged; *f*, do., from side.

Fig. 2. — *Pronuba maculata: a*, tip of female abdomen; *bjo*, basal joint of ovipositor; *tjo*, terminal joint do.; *ov*, oviduct; *mp*, max. palpus; *mt*, maxillary tentacle; *t*, tongue; *gs*, claspers of male from side; *gp*, do. from behind; *pr*, front wings showing arrangement of spots in two of the more common forms — hair-line showing nat. size.

PLATE 43.

Fig. 1. — *Prodoxus intermedius: a*, anal abd. joint of female — ×10; *bjo*, basal jt. ovipositor — ×40; *s*, its sculpture; *tjo*, terminal jt. do.; *ov*, oviduct.

Fig. 2. *Prodoxus marginatus: a*, anal abd. jt. of female —×26; *bjo*, basal jt. ovipositor; *tjo*, terminal jt. do.; *ov*, oviduct; *c*, claspers of male from above —×18; *pr*, front wing — hair-line showing nat. size.

Fig. 3. — *Prodoxus œnescens: a*, anal abd. jt. of female with ovipositor retracted —×15; *bjo*, basal jt. ovipositor; *tjo*, terminal jt. do. —×28; *ov*, oviduct; *c*, clasper of male from above —×18.

Fig. 4. — *Prodoxus cinereus:* male claspers (*a*) from above —×8; and (*b*) from side —×15.

Fig. 5. — *Prodoxus y-inversus: a*, left front wing — hair-line underneath showing natural size; *b*, genitalia of male, dorsal view —×14; *c*, do., lateral view —×18; *d*, anal joint of female with ovipositor exserted, lateral view —×20; *e*, tip of ovipositor still further enlarged.

Fig. 6. — *Prodoxus coloradensis: a*, left front wing — hair-line underneath showing natural size; *b*, male genitalia, dorsal view —×15; *c*, do., lateral view —×18.

Fig. 7. — *Prodoxus reticulatus:* female with wings expanded — hair-line showing natural size.

Fig. 1.

Fig. 2.

Fig. 3.

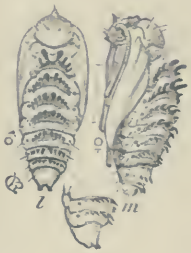


Fig. 4.

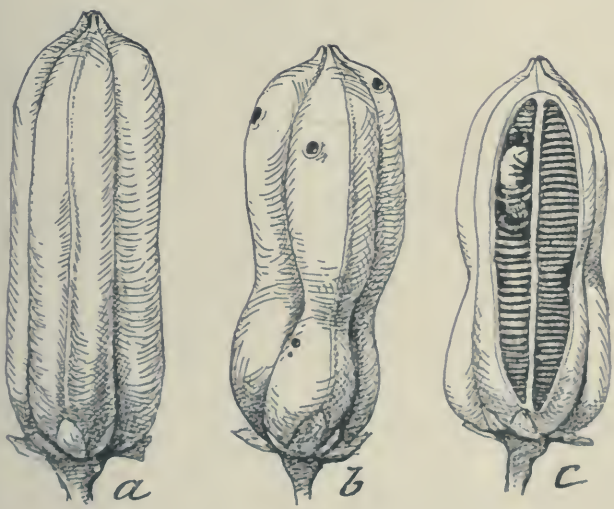


Fig. 5.

CHARACTERS OF PRONUBA YUCCASELLA.

Fig. 1.

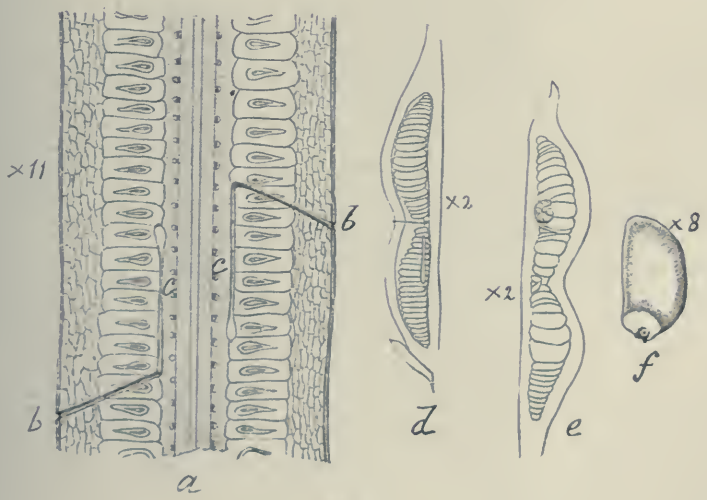


Fig. 2.

OVIPOSITION OF PRONUBA

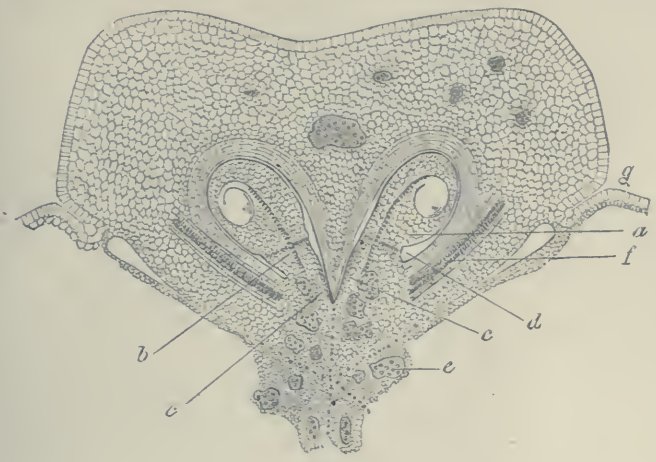


Fig. 1.

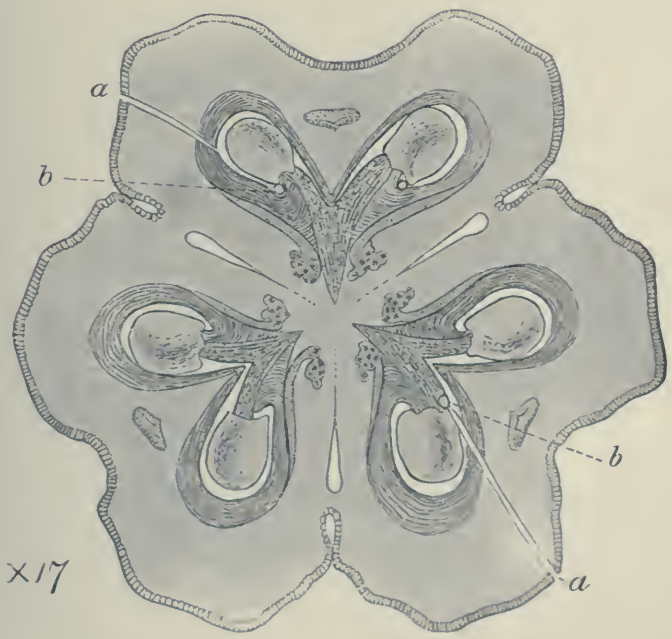


Fig. 2.

OVIPOSITION OF PRONUBA.

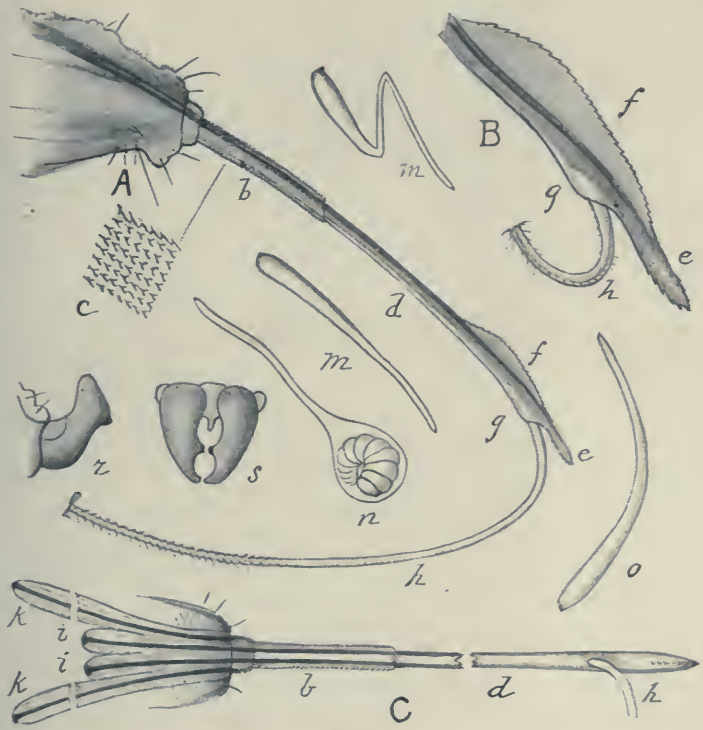


Fig. 1.

Fig. 2.

OVIPOSITION OF PRONUBA.

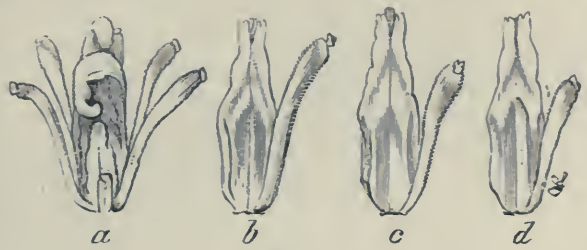


Fig. 1.

Fig. 2.

Fig. 4.

Fig. 3.

PRONUBA AND YUCCA POLLINATION.

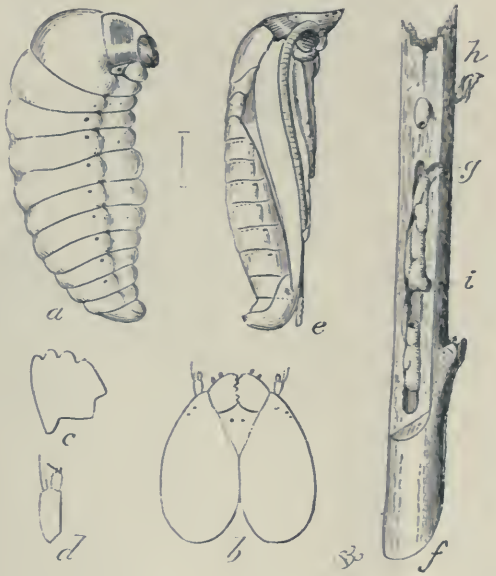


Fig. 1.

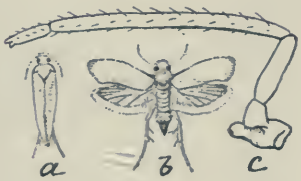


Fig. 2.

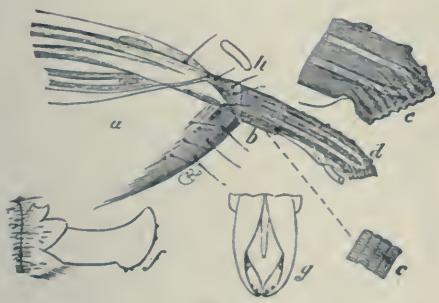


Fig. 3.

Fig. 4.

PRODOXUS DECIPIENS.

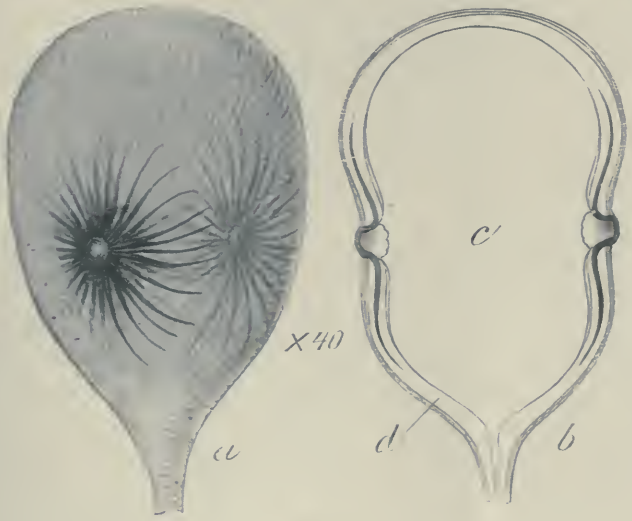


Fig. 1.

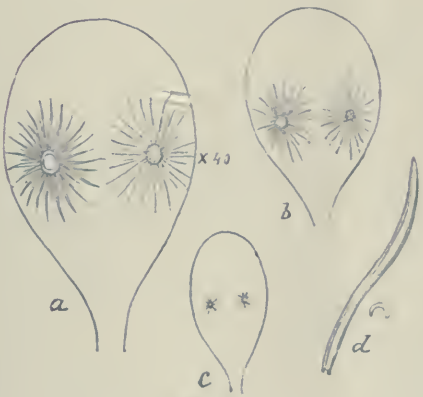


Fig. 2.

RADIATE ORGANS OF PRODOXIDÆ.

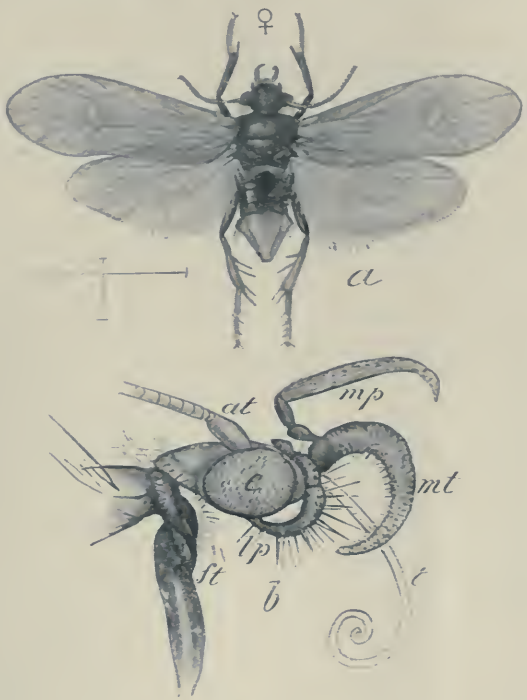


Fig. 1.

Fig. 2.

PRONUBA SYNTHETICA.

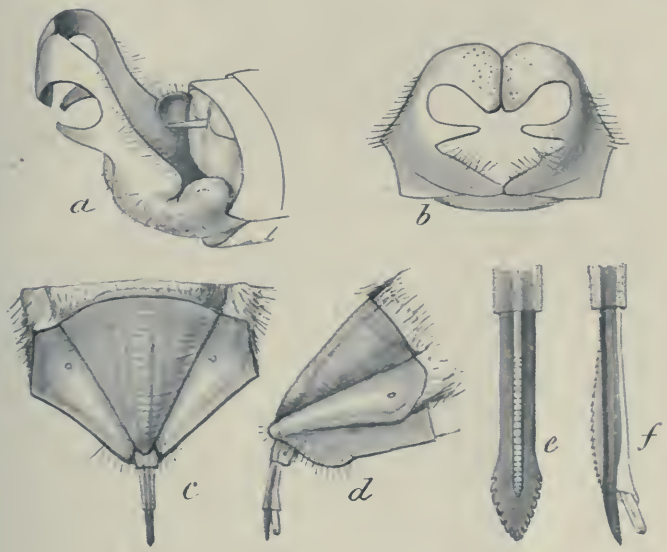


Fig. 1.

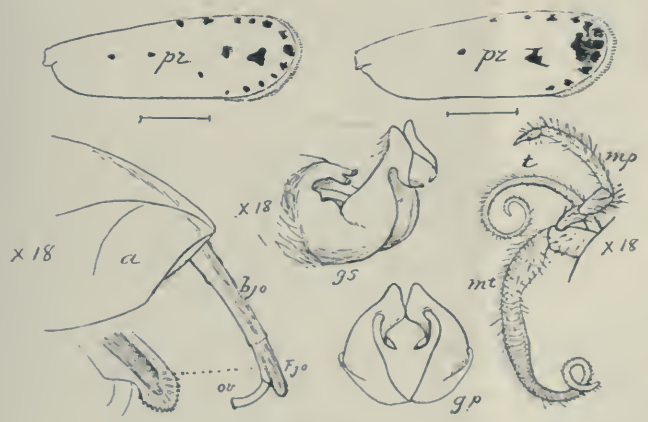


Fig. 2.

PRONUBA SYNTHETICA AND P. MACULATA.

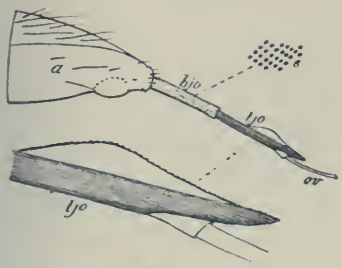


Fig. 1.

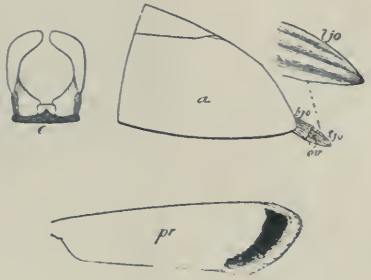


Fig. 2.

Fig. 3.

Fig. 4.

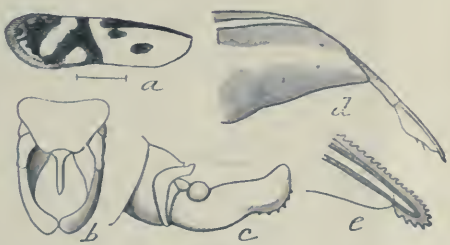


Fig. 5.

Fig. 6.

Fig. 7.

SPECIES OF PRODOXUS.

NOTES AND OBSERVATIONS.

1. DETAIL ILLUSTRATIONS OF YUCCA.

During the time that I have resided in St. Louis, I have many times had occasion to observe the principal facts connected with the pollination of *Yucca filamentosa* and the forms referred to that species by Dr. Engelmann, and to demonstrate them to visitors to the Garden. The Chairman of the Garden Committee of the institution, who viewed them in my company last spring, was so impressed with their interest that I made a short visit to the Rocky Mountains early in July last, for the purpose of making similar observations on *Y. angustifolia*, with the intention of summarizing for the present volume all that was known on the subject. On my return I found on my table a letter from Professor Riley, to whom, and Dr. Engelmann, the discovery and elaboration of the curious facts is due, offering to prepare for this report a paper such as I had in mind. As an account from his pen promised far greater completeness and interest than I could have hoped to attain, his offer was very gratefully accepted, and the article appears in the preceding pages.

While reviewing the material at the Garden bearing upon Yucca, I found a large number of drawings by Dr. Engelmann, which I had intended utilizing in connection with my paper; and as these sketches depict the floral and capsular structure of some species that have as yet been inadequately figured, I have had them redrawn in ink by Miss Grace E. Johnson for photo-engraving, and publish them herewith. I have included with them reproductions of photographs showing the habit of growth of several species, and also some figures illustrative of our observations on *Y. filamentosa*, which had been prepared before the receipt of Professor Riley's paper, and may prove of interest in connection with it.

Yucca is a small genus of evergreen leaved plants of the lily family, belonging to the Central American flora and that of the Southern United States, one species reaching well up into the Rocky Mountains. Engelmann recognized fourteen species, while Baker, who has also made the Yuccas the subject of much study, admits half as many more, several of the additional species having been called varieties by Engelmann, though several others are known only from plants in cultivation (few of which have flowered or fruited), and are regarded by some botanists as probable forms or derivatives of other species known in a state of nature.

While the more eastern of our species are short-stemmed, several of those native in the southwest become trees, often of considerable size and with thick rough bark. The fruit of the section with pulpy carpels is more or less eaten, and the fibers of the leaves are used for cordage by the Mexicans who also make a good deal of domestic use of the root-stocks as a substitute for soap. Some years since the proprietors of an English newspaper established a mill in the home of one of the tree Yuccas, intending to make paper pulp from its wood, but the enterprise was shortly abandoned.

Like most of the monocotyledons, aside from the palms, Yucca has left few if any fossil remains complete enough for certain determination, and Professor Lester F. Ward informs me that only one fossil species has ever been referred to the genus Yucca, — namely *Y. Roberti*, Bureau, found in the Paris basin, — and that even this is generally considered to belong to Yuccites, a form assemblage, some of the components of which are of very early origin, but none of them of necessity closely allied to the existing genus Yucca, nor representing its ancestral type.

The principal revisions of the genus are by Engelmann, in the Transactions of the St. Louis Academy, iii, pp. 17, 210 and 371 (brought together, with additional descriptions and notes printed elsewhere by him, in his Collected Writ-

ings, p. 276, — published under the auspices of the Garden in 1877); Baker, in the Journal of the Linnean Society, xviii, p. 219, and Kew Bulletin of Miscellaneous Information, Jan. 1892, p. 7; and Watson, in the Proceedings of the American Academy, xiv, p. 251. Reference should be made to these papers, and to Professor Sargent's Forest Trees of North America, p. 218, for the synonymy and bibliography of each species, since only the more recent figures are referred to here. The retention of varietal names for forms subsequently raised to specific rank would involve certain changes in the nomenclature, which are indicated under the species affected.

No better general classification of the Yuccas that are actually known has been found than the following, which represents Engelmann's views, except that by general consent *Y. filifera* has been raised to specific rank from a variety of *Y. baccata*, where Engelmann left it, while Mr. Brandegee has added *Y. valida*, from Mexico, and Baker has just added from the gardens of the Riviera *Y. Hanburii*, said to be from Rocky Mountain seed.

From an examination of this enumeration of species, in connection with the accompanying plates and the figures cited, it will be seen that we are still unpossessed of a knowledge of the floral and fruit details of several species, while some of the figures drawn from dried specimens may be inaccurate in some degree; so that persons who have it in their power to secure faithful photographs or drawings from growing plants may materially contribute to a correct knowledge of this difficult group by supplying the deficiencies, and they may further the same end by obtaining ripe seeds for cultivation in botanical gardens.

SYNOPTICAL LIST.

* Euyucca. — Styles stout, the connivent apexes forming a more or less developed central stigmatic cavity: filaments papillate.

A. *Sarcoyucca.* — Fruit pendent, fleshy and indehiscent: ovules and seeds thick, marginless: albumen ruminated.

Y. aloifolia, L. Sp. i. (1753), 319; Engelm. Coll. Writings, 287; Watson, *l. c.* 251; Baker, *l. c.* 221; Nicholson Gard. Dict. 228. — Plates 7 & 44.

Y. Yucatana, Engelm. Trans. St. L. Acad. iii. (1873), 37, and reprint 288; Watson, *l. c.* 251; Baker, *l. c.* 221. —Plate 45.

Y. Guatemalensis, Baker, Refugium Botanicum, v. (1872), pl. 313, and Journ. Linn. Soc. *l. c.* 222; Engelmann, *l. c.* 289; Watson, *l. c.* 251; Nicholson, *l. c.* 233.

Y. Schottii, Engelm. Trans. St. L. Acad. iii. (1873), 46, and *l. c.* 292, 300; Watson, *l. c.* 252; Baker, *l. c.* 228.

Y. macrocarpa, Engelm. Bot. Gaz. vi. (1881), 224, and *l. c.* 299 and 300; Nicholson, *l. c.* 234; Baker, Kew Bull. 1892, 8. —Plate 46. (Perhaps only the well developed form of the preceding).

Y. valida, Brandegee, Proc. Calif. Acad. (2), ii. (1889), 208, plate 11; abst. in Garden & Forest, iii. 106.

Y. Treculeana, Carr. Rev. Hort. vii. (1858), 280; Engelm. *l. c.* 290; Watson, *l. c.* 252; Baker, *l. c.* 226; Sargent, *l. c.* 218, and Garden & Forest, i. 54 (with figure of habit); Pringle, Garden & Forest, iii. 338; Nicholson, *l. c.* 234, f. 250. —Plates 1 & 47.

Y. baccata, Torr. Bot. Mex. Bound. (1858), 221; Engelm. *l. c.* 276, 291, 300; Watson, *l. c.* 252; Baker, *l. c.* 229; Parish, Garden & Forest, iv. 136; Nicholson, *l. c.* 229. —Plates 2 & 48.

Y. filifera, Chabaud, Rev. Hort. 1876, 432; Nicholson, *l. c.* 232, fig. 243, 244; Sargent, Gard. & Forest, i. 78 (with habit figures), and iv. 324 and 396; Baker, Bot. Mag. (3), xlvii. pl. 7197. — *Y. baccata*, var. *australis*, Engelm. Trans. St. L. Acad. iii. (1873), 44, and *l. c.* 291; Watson, *l. c.* 252; Baker, *l. c.* 229. — An adoption of the varietal name, which has priority, would cause the plant to be known as *Y. australis* (Engelm). —Plates 3 & 4.

(Y. Desmetiana, Baker, Gard. Chron. 1870, 1217, Journ. Linn. Soc. *l. c.* 222, and Kew Bull. 1892, 8, Engelmann, *l. c.* 290; and Y. Peacockii, Baker, *l. c.* 223, and Kew Bull.

l. c. 8, are species unknown in flower, but perhaps belonging to the group Sarcoyucca.)

B. *Clistoyucca.*—Fruit pendent (or erect in the first), dry and coriaceous but indehiscent: ovules and seeds thinner, marginless: albumen entire.

Y. brevifolia, Engelm. Bot. King (1871), 496; *l. c.* 276, 293, 297, 298; Watson, *l. c.* 252; Baker, *l. c.* 221; Sargent, *l. c.* 218; Parish, Gard. & Forest, iv. 135. — *Y. Draconis*, ? var. *arborescens*, Torr. Botany of Whipple in Rept. Pac. R. R. Surv. iv. (1857), 147. — If the varietal name were adopted, this would be *Y. arborescens* (Torr.) —Plates 5 & 49.

Y. gloriosa, L. Sp. i. (1753), 319; Engelm. *l. c.* 289, 297; Watson, *l. c.* 251; Baker, *l. c.* 225; Nicholson, *l. c.* 232, f. 247–249.—Plates 6, 7 & 50.

C. *Chœnoyucca.*—Fruit erect, capsular with septicidal dehiscence: ovules and seeds thin, the latter broadly wing-margined: albumen entire.

Y. rupicola, Scheele, Linnæa, xxiii. (1850),143; Engelm. *l. c.* 293; Watson, *l. c.* 253; Baker, *l. c.* 222, and Bot. Mag. (3), xlvii. pl. 7172; Nicholson, *l. c.* 234.— Plate 51.

Y. angustifolia, Pursh, Fl. (1814), 227; Engelm. *l. c.* 276, 294; Watson, *l. c.* 253; Baker *l. c.* 226; Sargent, Gard. & For. ii. 244, 247 (habit figures); Nicholson, *l. c.* 228, f. 238 & 239.—Plates 8 & 51.

Y. elata, Engelm. Bot. Gaz. vii. (1882), 17; *l. c.* 299; Sargent, *l. c.* 219, and Gard. & For. ii. 368 (with habit figures). — *Y. angustifolia*, var. *elata*, Engelm. Proc. St. L. Acad. iii. (1873), 50; *l. c.* 294. — *Y. angustifolia*, var. *radiosa*, Engelm. Bot. King (1871), 496. — The rule of priority, if applied to varietal names, would make this *Y. radiosa* (Engelm.)—Plate 9.

Y. filamentosa, L. Sp. i. (1753), 319; Engelm. *l. c.* 295; Watson, *l. c.* 254; Baker, *l. c.* 227; Nicholson, *l. c.* 231, f. 240–242.—Plates 10, 52 & 53.

(Y. Hanburii, Baker, Kew Bull. 1892, 8, from the de-

scription of foliage characters would appear to belong to the group Chænoyucca, but its flower and fruit are unknown.)

* * Hesperoyucca. — Style slender, with an expanded peltate or thimble shaped stigma: filaments glabrous.

Y. Whipplei, Torr. Bot. Mex. Bound. (1859), 222; Engelm. *l. c.* 277, 296, 297, 298; Watson, *l. c.* 254; Baker, *l. c.* 230; Revue Horticole, 1884, 324; Nicholson, *l. c.* 234. — Plates 11, 12 & 54. — Baker, in Kew Bulletin, January 1892, 8, proposes to separate this from Yucca, under the generic name Hesperoyucca.

Explanation of Plates Illustrative of Yucca.

Plate 1. *Y. Treculeana.* — Plant blooming at the Villa Thuret, Antibes, France, in 1876.

Plate 2. *Y. baccata.* — From a photograph taken near San Diego, Cal., Mar. 16, 1876, by Parker, × $\frac{1}{30}$.

Plate 3. *Y. filifera.* — Young plants cultivated at the Villa Thuret, Antibes, France, in 1876.

Plate 4. *Y. filifera.* — Plants blooming at the Villa Thuret in 1891, from a photograph furnished by Professor Naudin.

Plate 5. *Y. brevifolia.* — Plant in the desert east of the Sierra Nevada, × $\frac{1}{60}$; from photograph presented by Dr. Parry in 1867.

Plate 6. *Y. gloriosa.* — Specimen blooming at the Villa Thuret, Antibes, France, in 1876. (The original of a cut published in the Gardeners' Chronicle, June 30, 1883.)

Plate 7. *a. Y. aloifolia; b. Y. gloriosa.* — From a photograph of fruiting plants taken in 1872, on the grounds of the Department of Agriculture, × $\frac{1}{17}$.

Plate 8. *Y. angustifolia.* — Fruiting plants on the mountains near Manitou, Col., July, 1891.

Plate 9. *Y. elata.* — Flowering specimen on the plains of Arizona, photographed by Pringle. Copied, by permission, from Garden & Forest, ii. 569.

Plate 10. *Y. filamentosa.* — Plants blooming in the Missouri Botanical Garden, June, 1891.

Plate 11. *Y. Whipplei.* — Plants beginning to bloom, × $\frac{1}{25}$, from a photograph by Parker, Apr. 13, 1876, near San Diego, Cal.

Plate 12. *Y. Whipplei.* — Plants in full bloom, × $\frac{1}{25}$, from a photograph taken near San Luis Obispo, Cal., in 1873, by Dr. W. W. Hays.

Plate 44. *Y. aloifolia.* — 1. Stamen and pistil, × 2; 2, ends, and 3, side view and section, of fruit, natural size; 4, sections of seed, × 2. — After Engelmann.

Plate 45. *Y. Yucatana.* — 1, Habit, after a sketch by Schott in 1865; 2 and 3, flowers, natural size; 4, stamens and pistil, × 2; 5, leaf margin, × 15. — After Engelmann.

Plate 46. *Y. macrocarpa.* — Two fruits, natural size. — After Engelmann.

Plate 47. *Y. Treculeana.* — 1, Flower, natural size; 2, stigma, × 2; 3, fruit, and 4, cross section of same, natural size; 5, sections of seed, × 2. — After Engelmann.

Plate 48. *Y. baccata.* — 1, Stamen and pistil, natural size, and cross section of ovary, × 2; 2, fruit, natural size; 3, sections of same, reduced one-half; 4, sections of seed, × 2. — After Engelmann.

Plate 49. *Y. brevifolia.* — 1, Margin of leaf, × 15; 2, pistil, natural size; 3, stamens, × 5; 4, fruit, and 5, end view of same, natural size; 6, sections of seed, × 2. — After Engelmann.

Plate 50. *Y. gloriosa.* — 1, Flower, natural size; 2, pistil and cross sections of same, × 2; 3, fruit, and section of same, natural size (from photographs of the Washington fruit of plate 7, *b*); 4, sections of seed, × 2. — After Engelmann.

Plate 51. 1–4, *Y. rupicola;* 5–7, *Y. angustifolia.* — 1, Symmetrical capsules, natural size; 2, section of seed, × 2; 3, margin of leaf of var. *rigida*, × 15, and 4, prominence of same, × 75. — 5, Stamens and pistil, natural size;

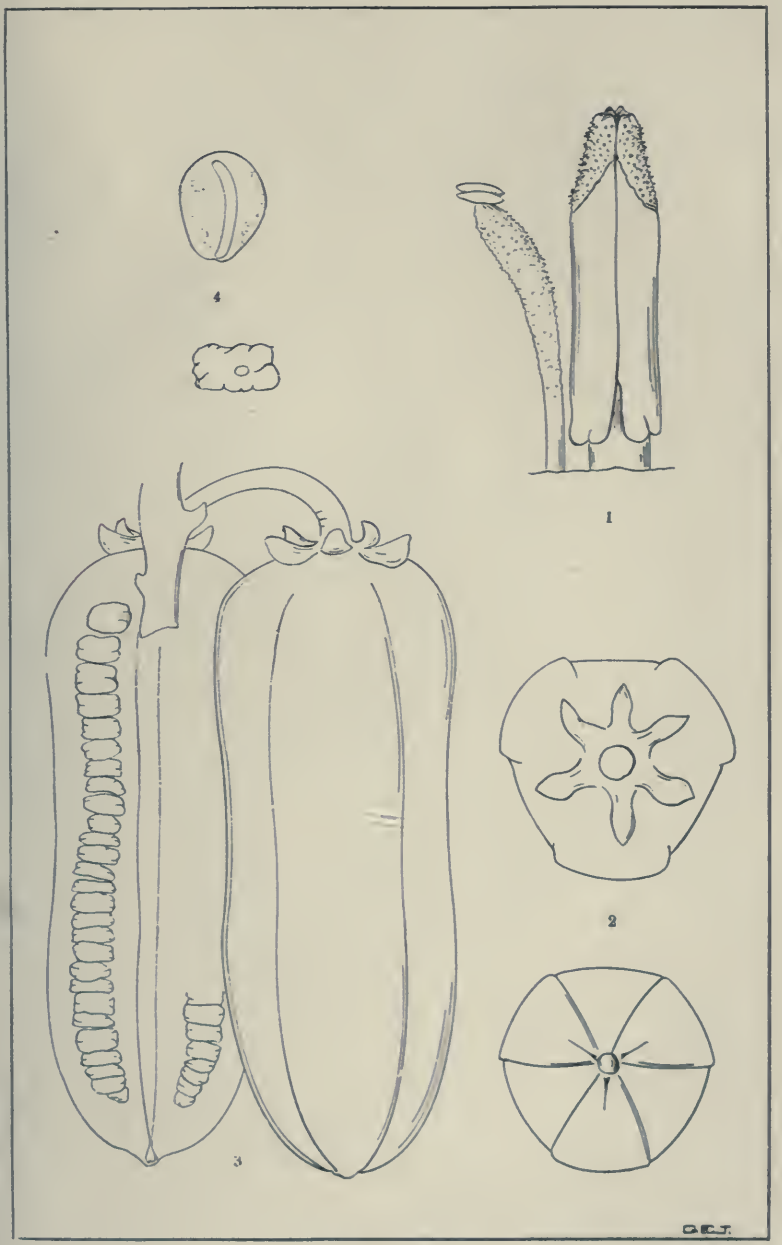
6, symmetrical capsule, natural size; 7, sections of seed, × 2. — After Engelmann.

Plate 52. *Y. filamentosa.* — 1, Sections of pistil at various heights, showing connection of stigmatic chamber with ovarian cells, × 2; 2, stigma, × 3; 3, stamen before and after dehiscence, enlarged; 4, Pronuba larva *in situ* in nearly mature capsule, natural size; 5, young ovules bored by larva, enlarged; 6, capsule (too symmetrical) after escape of larvæ, natural size; 7, seed and sections, × 2; 8, developing egg of Pronuba, × 30. — 1 and 5 to 8, after Engelmann; the remainder from nature by Miss Johnson.

Plate 53. *Y. filamentosa.* — 1, Pistil at time of fertilization, in longitudinal section, showing on the right development of pollen tubes through the stylar channel into ovary, and on the left the septal nectar gland A, with its duct, B, and outlet C, × 5; 2, part of cross section at A B, showing below, the outer portion of septal gland, and above, the duct B and its outward closure by the surface papillæ of ovary, × 75; 3, pollen tube, × 150; 4, emergence of same from extine of pollen grain, and 5, distal end of same, showing the not infrequent occlusion of cell cavity, both × 400; 6, apex of ovule in longitudinal section, showing egg apparatus and entering pollen tube, × 400. — 3 and 4 after Engelmann, the remainder from nature by Mr. Webber.

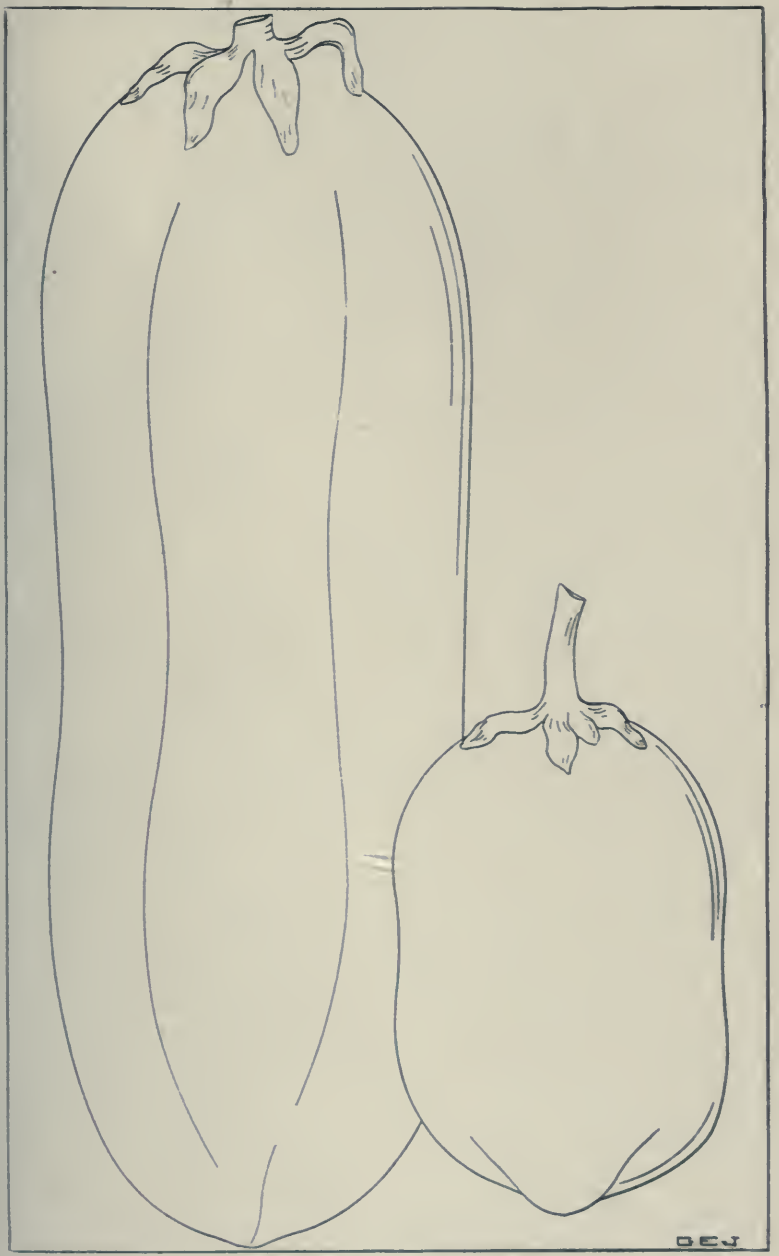
Plate 54. *Y. Whipplei.* — 1, Section of flower, and 2, side view of pistil, — from the Gardeners' Chronicle; 3, pistil, 4, section of stigma, 5, section of ovary, and 6, stamen, enlarged; 7, capsule, natural size; 8, sections of seed, × 2. — After Engelmann.

W. T.

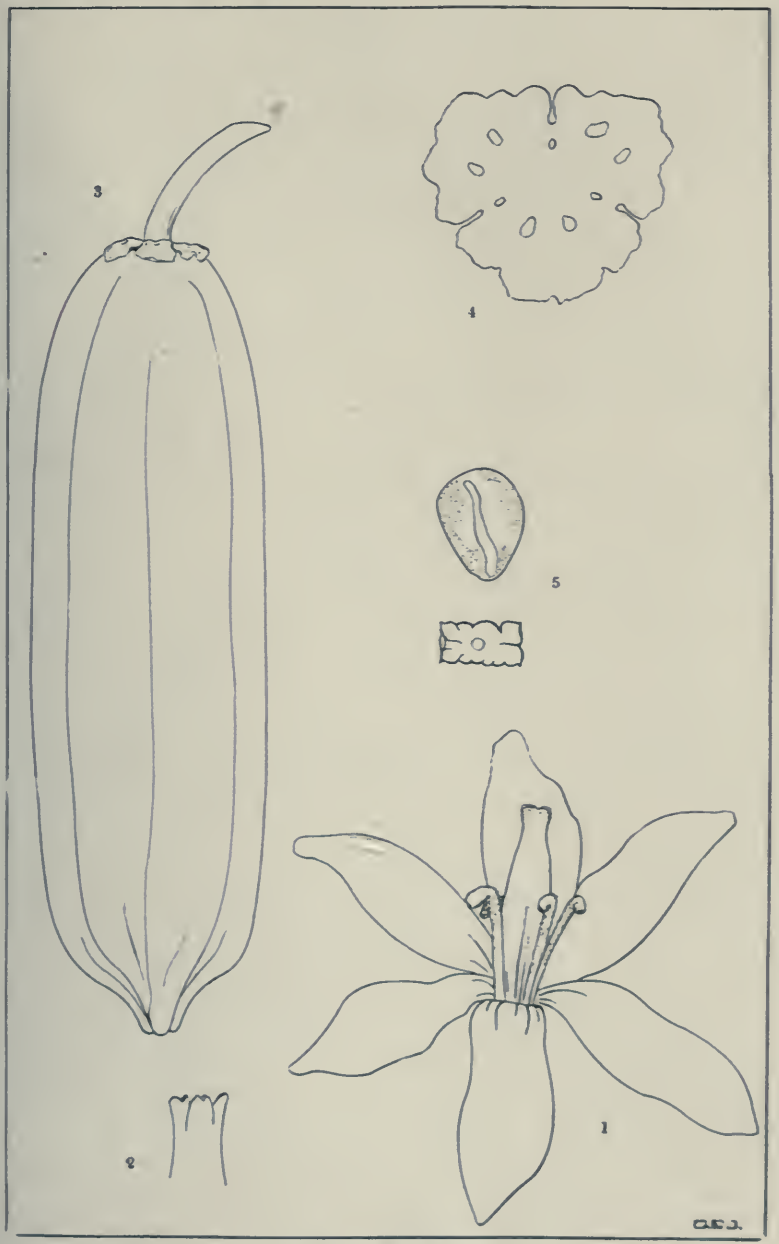


YUCCA ALOIFOLIA.

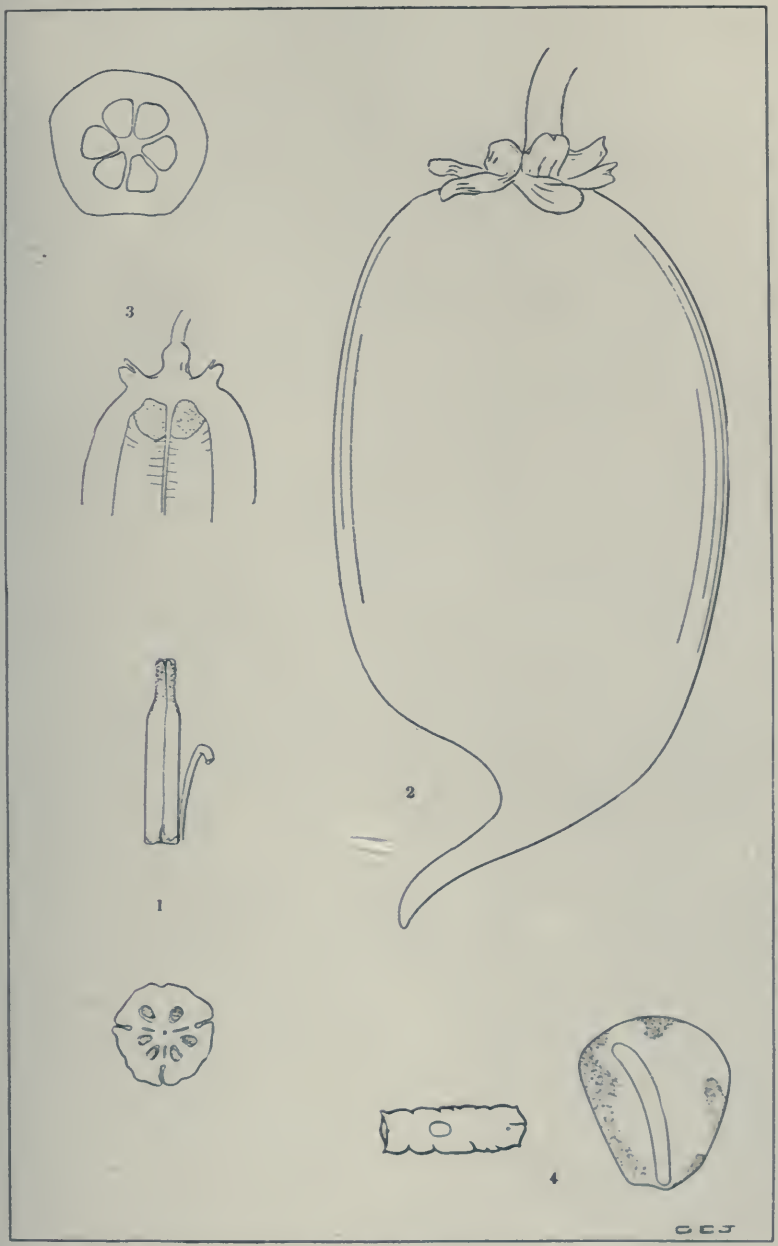
YUCCA YUCATANA.



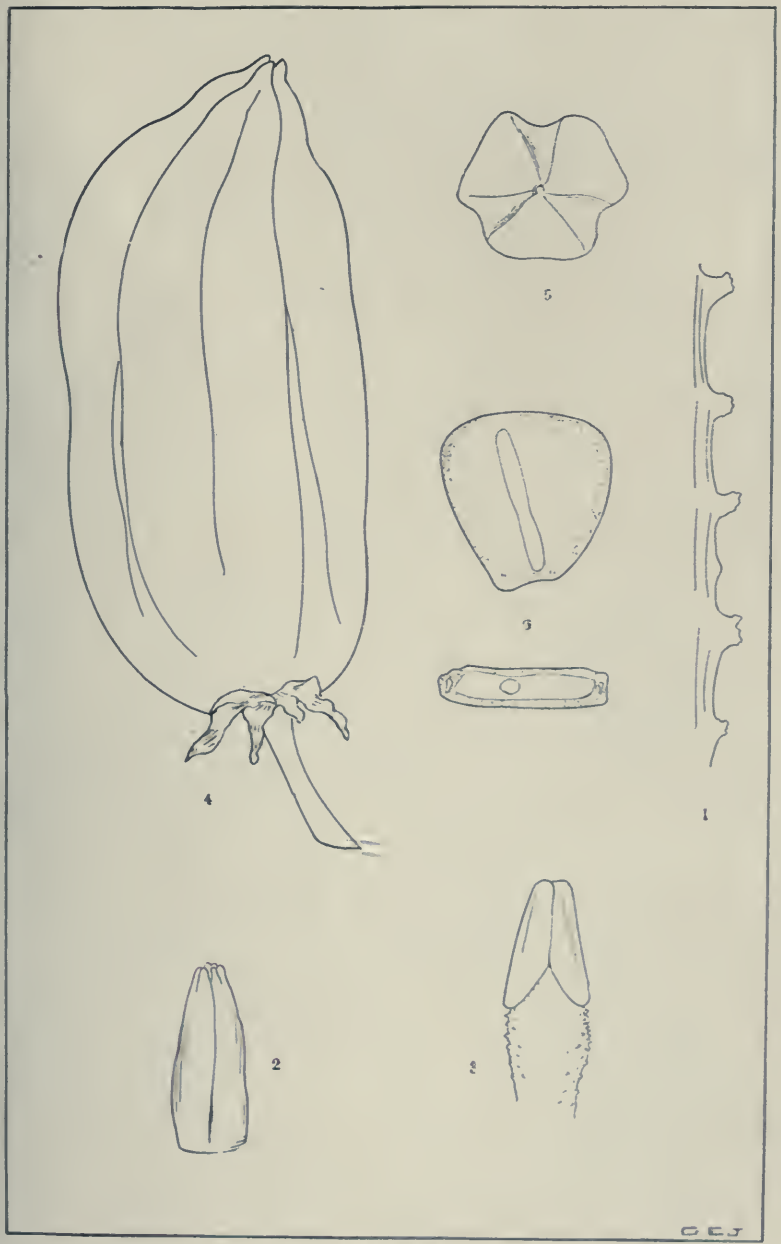
YUCCA MACROCARPA.



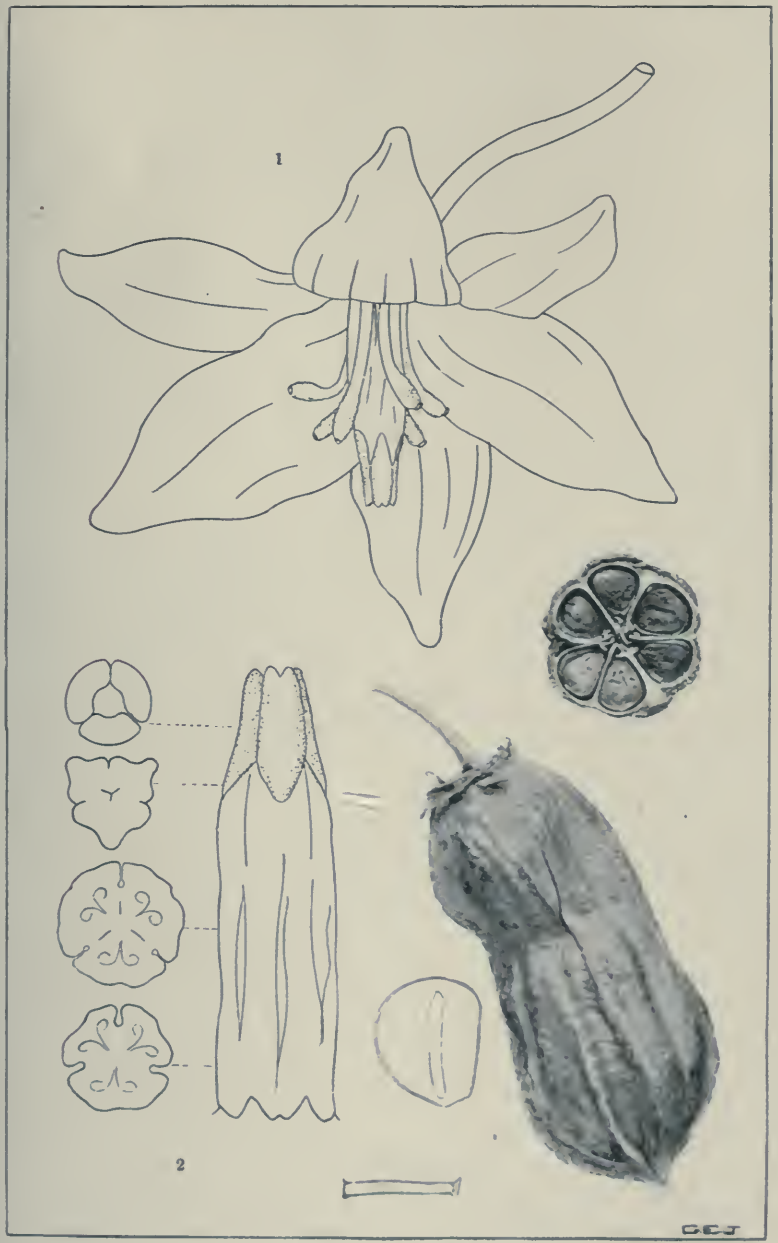
YUCCA TRECULEANA.



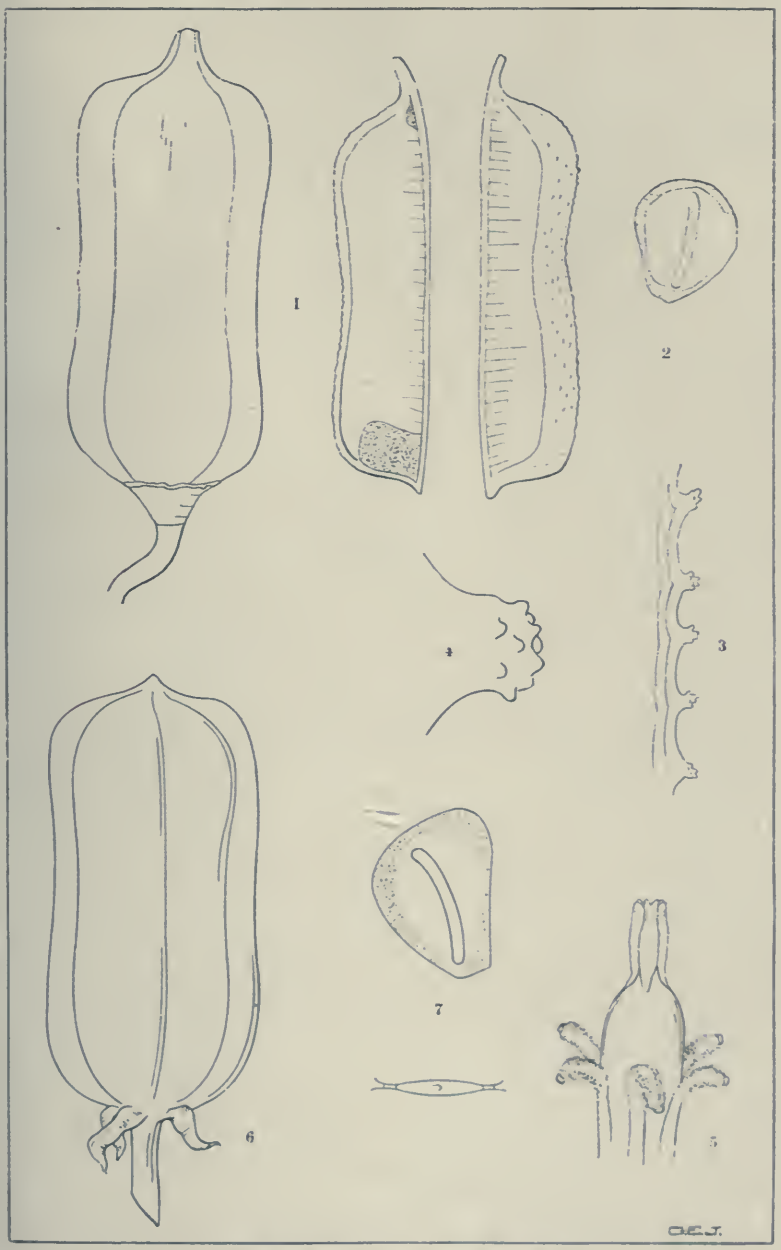
YUCCA BACCATA.



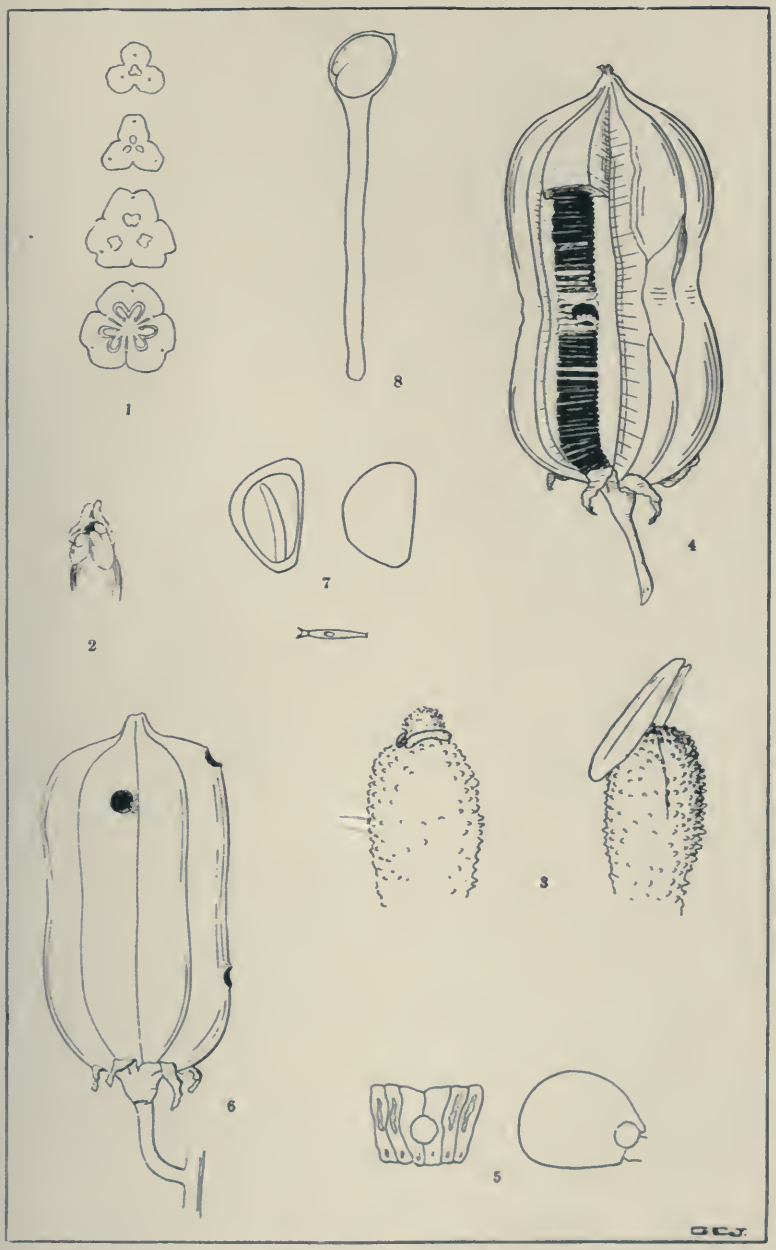
YUCCA BREVIFOLIA.



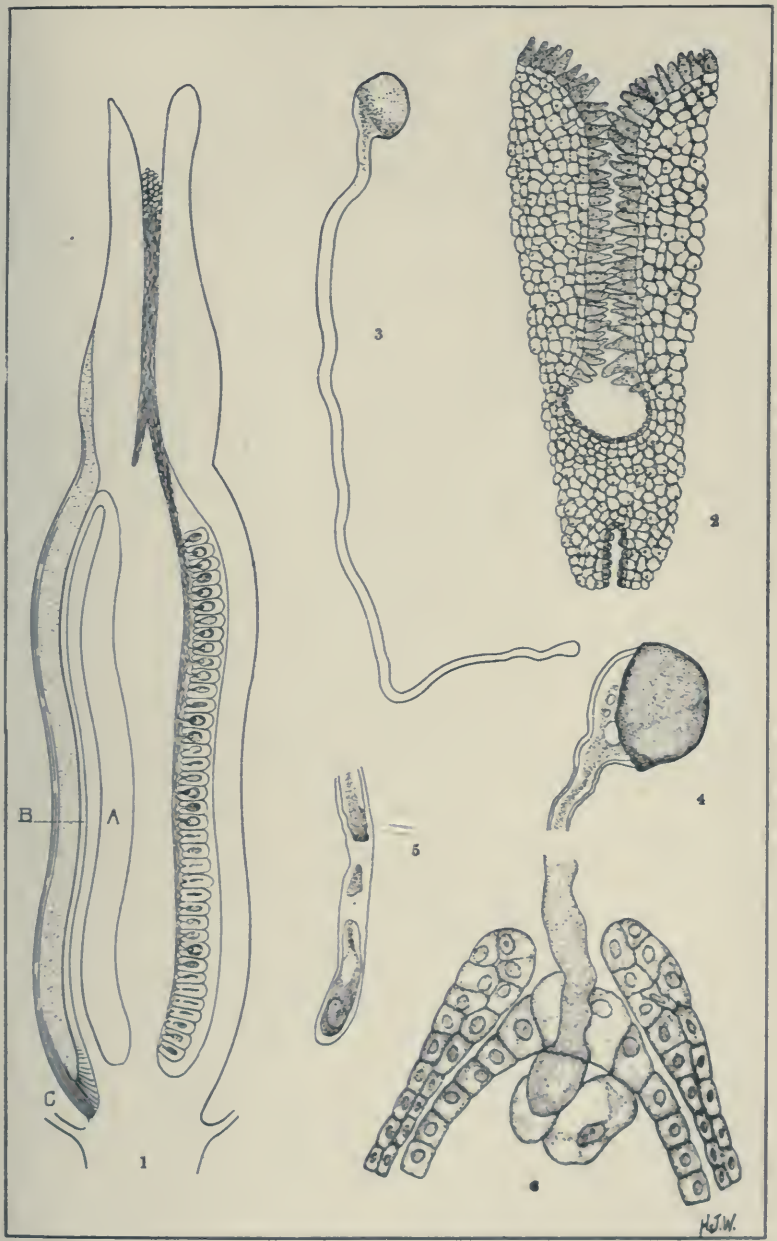
YUCCA GLORIOSA.



YUCCA RUPICOLA AND ANGUSTIFOLIA.



YUCCA FILAMENTOSA.



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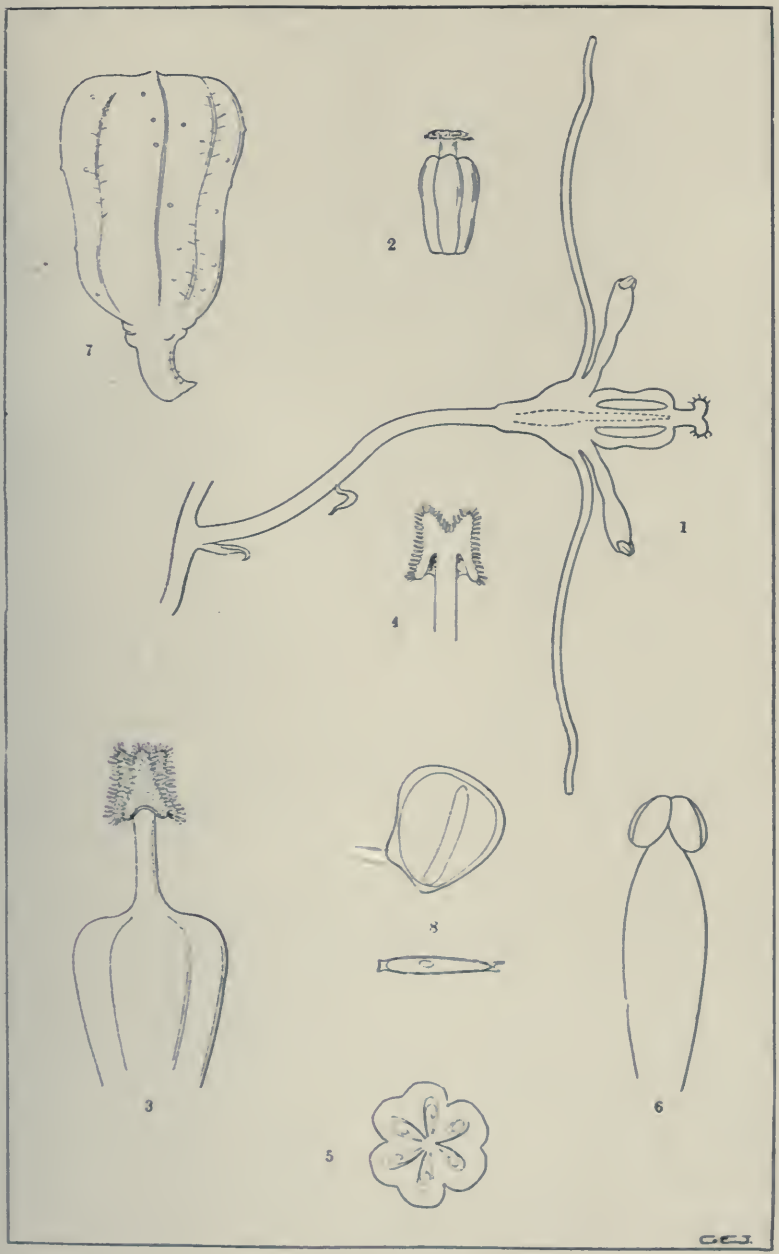

YUCCA WHIPPLEI.

2. Agave Engelmanni, n. sp.

In 1884, shortly before his death, Dr. George Engelmann visited the late Josiah Hoopes, and received from him several very small seedling Agaves. One of these, which bore the name *A. attenuata*, var. *subdentata*, was placed at the Botanical Garden, where it reached apparently good development, and bloomed and (with artificial pollination) fruited in January, 1891, thus affording an opportunity for determining its true affinities. As was evident even from the leaf characters, it could not properly be referred to any form of *A. attenuata;* and an examination of the complete material last winter led to the conviction that it was an unnamed species, a conclusion shared by Mr. Baker, of Kew Gardens, to whom photographs and specimens were sent. In connection with a reproduction of a photograph showing the habit of the flowering plant, and a plate of details, the following description of the species is offered, and I take pleasure in dedicating it to the memory of its donor, a botanist whose writings on the Agaves are classical.

Agave Engelmanni, Trelease, n. sp. *A. attenuata*, var. *subdentata*, Hort. Hoopes.). — Acaulescent; leaves about 30, in a rosette 3 ft. broad and 18 in. high, deep green, transiently somewhat glaucous, rather thin and not very rigid, oblanceolate-spatulate, commonly recurved, the upper surface concave, 6 to 7 in. wide by about 2 ft. long, reduced to 3 in. wide and 1½ in. thick near base, acuminate, the brown purple end spine channeled and decurrent for a short distance as a very narrow dark margin connecting the small deltoid slightly reflexed teeth, which further down are quite distinct; scape about 7 ft. high, the upper two-thirds floriferous; panicle narrowly oblong, the short ascending branches densely few flowered; perianth yellowish green, about an inch long, equalling the ovary and with funnel shaped tube; style and stamens exserted for about 1 in., the former finally double this length; capsules clustered, mostly about an inch long; seeds 3x5 mm. and about one-half millimeter thick. Native country unknown. — Plate 55, flowering plant, about one-twentieth natural size. Plate 56, two leaves representing extremes,

one-fourth natural size; apex and marginal teeth, natural size; young (functionally staminate) and old (functionally pistillate) flowers, natural size; capsules (rather smaller that usual), natural size; seed from side and edge, and in section, x 2.

Agave Engelmanni belongs to the foliage group *Rigidæ*, but has rather more flexible leaves than are common in that group; and in the absence of floral characters would be placed beside or united with *A. densiflora* or the scarcely distinct *A. polyacantha*. That species, however, is a typical but very densely flowered representative of the group *Littæa*,— the *Geminiflorœ* of Engelmann. *A. Engelmanni*, on the other hand, though it possesses the oblong inflorescence of that group, has its flowers aggregated in unmistakable clusters for the most part elevated on well marked common peduncles, so that it must be classed with the species constituting the group *Euagave*, — the *Paniculatæ* of Engelmann,— which, to a certain extent, it thus brings into connection with *Littæa*. The latter, moreover, occasionally has the lowest flowers in sessile groups of three, while Engelmann describes in the Gardeners' Chronicle for 1883, xix, 48, a form of *A. heteracantha* with the capsules clustered on very evident common peduncles.

At present no light can be thrown on the origin of this species, which, as has been said, is in no sense related to *A. attenuata*. The only reference I find to a variety *subdentata* under the latter, is in the catalogue of Cels of Paris, for 1865, p. 17. Possibly the seedling here described may have originally come from that house.

W. T.

AGAVE ENGELMANNI.

AGAVE ENGELMANNI.

3. Parmelia molliuscula, Ach.

This species* was described by Acharius from specimens collected by Thunberg at the Cape of Good Hope. Nylander has reported it from Peru. According to Tuckerman the specimens of *Borrera camtschadalis* (in Herb. Sprengel.) from Soongaria, *Parmelia congruens* (in Herb. Floerk.) collected by Tilesius in Kamtschatka, and *Parmelia vagans*, Nyl. (in Herb. Krempelhüber.) from the Steppes of the Volga in Russia, belong to this species. It is found plentifully on sterile calcareous or sandy soils from the Badlands of the Dakotas and Nebraska to the Rocky Mountains. It has then a very wide distribution, having been found in Europe, Asia, Africa, and North and South America. In spite of the fact that it has been collected in so many localities, it has heretofore been reported as "always sterile."

The original description of Acharius in his Lichenographia Universalis, p. 492, 1810, is as follows: —

Thallo substellato molliusculo sordide albido-virescente subpulverulento, subtus concolori, laciniis imbricatis convexiusculis linearimultifidis ad apices subtus subcanaliculatis.

Habitat ad terram juxta Promontor. bonae sp. Africae.

Obs. Thallus vix stellatus nudus aut pulvere concolori adspersus. Laciniae crassiusculae molliores, substantia corticali facile tamen fragibili, lineares pinnatifidae digitato-palmatae, ad apices subtus planae vel canaliculatae ibidemque fibrillis quibusdam obsitae. Apothecia non vidi.

In Observations on N. A. Lichens, Proc. Amer. Acad., Vol. IV, p. 383, 1860, Tuckerman described a lichen, collected by Hayden and others on the western plains, under the name of *Parmelia chlorochroa*. He gave it the following description: —

* Acharius, Lich. Universalis, p. 492, 1810; Nylander, Syn. I, p. 393; Tuckerman, Syn. N. Amer. Lich. I, p. 64.— *Parmelia chlorochroa*, Tuckerman, Obs. Lich., Proc. Amer. Acad., Vol. IV, p. 383.

Thallo substellato-multifido decumbente coriaceo laevi nudo flavo-virescente (stramineo) laciniis discretis laxe intricatis repetito-dichotomis marginibus recurvis (conniventibus) subtus fuscis (nigrescentibus) fibrillis nigris subpannosis; apotheciis. . . . . .

In his Genera Lichenum he mentions this same lichen, but concludes that it belongs to *Parmelia molliuscula*, Ach. In his synopsis of North American Lichens, I, p. 64, he still holds to this last determination and gives the following description: —

Parmelia molliuscula, Ach.; Everniaeform, the narrowed lobes sub stellate, or loosely intricate, dichotomously more or less regularly divided, convex; beneath channeled, or the margins connivent, and densely, or now obsoletely fibrillose; apothecia unknown.

Recently while looking over the lichens of the Engelmann Herbarium at the Missouri Botanical Garden, a couple of fragments of this species were found bearing several apothecia. The specimens are from Upper Pole Creek in the Black Hills region, and were collected by Dr. H. Engelmann, August, 1856.

A study of these specimens enables us to add to the foregoing descriptions: — Apothecia middling size; disk dark chestnut brown, becoming flattish; margin often at first entire, but soon becoming subcrenate.

A careful study of numerous sections of the best developed apothecia failed to show any mature spores *in situ*. Nearly all the asci contained shrunken masses of protoplasm and many of them showed the beginning of spore differentiation.

A few loose spores were found, however, that probably belong to this species. They were simple, colorless, ellipsoid, and measured 10 μ. long by 5 μ. in width.

Plate 57 shows a sterile thallus above, and below, the fertile specimens referred to, x 2; a cross section through a medium sized apothecium near the revolute margin, x 10; and an ascus showing incipient spore formation, with a cluster of three paraphyses, x 650.

T. A. Williams.

PARMELIA MOLLIUSCULA.